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Contributions to the Embryology of Commelinaceae I.

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Introduction

Commelinaceae comprise 37 genera and about 600 species (Lawrence, 1951). Schnarf (1931) summarised the earlier literature on the embryology of this family. Later contributions on the embryology were by Maheshwari and Singh (1934), Murthy (1934, 1938), Parke (1935), McCollum (1939), Tschermak-woese (1947), Soueges (1958*a*, *b*), Maheshwari and Baldev (1958) and Chikkannaiah (1961, 1962, 1963, 1964, 1965).

The salient embryological features of the family are: Amoeboid anther tapetum; successive type of division of pollen mother cells; isobilateral pollen tetrads; 2-celled pollen; orthotropous, anatropous or campylotropous ovules with or without a parietal cell; mono-, bi-, or tetrasporic types of embryo sac development; nuclear type of endosperm; Asterad type of embryogeny, and endospermic seeds with a seed coat formed by both the integuments.

The present paper deals with the embryology of *Aneilema montanum* (Wight) C. B. Cl., *A. scaberrimum* (Bl.) Kunth., *Commelina attenuata* Koen., *Cyanotis axillaris* (Linn.) Schult. f., *C. cucullata* Kunth., *C. fasciculata* (Heyne ex Roth) Schult. f., *C. papilionaecea* (Linn.) R. and S., *C. tuberosa* (Roxb.) Schult. f., *Murdannia divergens* Bruckn., *M. nudiflora* (Linn.) Brenan, *Pollia subumbellata* C. B. Cl. and *Streptolirion volubile* Edgew.

Materials and methods

The materials were fixed in Formalin-acetic-alcohol. Usual methods of dehydration, infiltration and embedding were followed. Sections cut at thicknesses of 7–12 microns were stained in Delafield's haematoxylin using erythrosin as counterstain.

Organogeny

The organogeny of the flower has been studied in *Cyanotis axillaris*, *C. cucullata* and *Pollia subumbellata* and the floral parts originate in an acropetalous succession. (Figs. 1-6).

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Microsporogenesis and male gametophyte

The anthers are tetralocular. The differentiated anther shows an epidermis, three wall layers and the sporogenous tissue (Figs. 7, 8). The hypodermal wall layer functions as endothecium, the cells of which develop fibrous thickenings at maturity (Fig. 10) or they may be band-like as in *Cyanotis* species and *Streptolirion volubile* (Fig. 9). The middle layer becomes crushed during the development of the anther (Figs. 9, 10). The innermost wall layer functions as the tapetum which surrounds the sporogenous tissue in early stages (Figs. 7, 8). As the microsporocytes undergo meiosis the cells of the tapteal layer break down and their protoplasts coalesce to form the periplasmodium (Figs. 9, 10). It is completely absorbed by the time the pollen grains attain maturity.

The sporogenous cells divide and form a mass of sporogenous tissue (Figs. 7, 8). These cells enlarge to form the microsporocytes (Fig. 11) and undergo the usual meiotic divisions (Figs. 11 to 13). Cytokinesis takes place by successive cell plate formation (Figs. 14-17). The tetrads are mostly isobilateral (Figs. 18 20). Rarely decussate tetrads have been observed (Fig. 21). Tetrahedral tetrads have also been reported in the family (Maheshwari and Singh, 1934; Murthy, 1934, 1938).

The young microspores are ovoid and they develop a thick exine (Fig. 22). The cytoplasm after sometime becomes vacuolate and the nucleus is shifted to a corner, where it divides (Fig. 23) forming a small generative cell which is separated from the large vegetative cell by a thin sheath of cytoplasm (Figs. 24–26). Later, it detatches itself from the wall of the pollen grain and comes to lie in the vegetative cytoplasm (Figs. 27-29). The generative cell becomes much elongated (Fig. 30). The vegetative nucleus at this stage usually appears as a dark structure and has an irregular outline(Fig. 30). In *Cyanotis cucullata* however, the vegetative nucleus appears healthy. The pollen grains are monocolpate and 2-celled at the shedding stage. According to Chikkannaiah (1962) pollen grains in *Floscopa scadens* are 3-celled at maturity. The exine is warty (Figs. 29, 30) in *Cyanotis* species, *Murdannia nudiflora, Streptolirion volubile, Aneilema montanum* and *A. scaberrimum* and spinulose in *Commelina attenuata* (present study), *C. subulata* and *Floscopa scandens* (Chikkannaiah, 1962).

Ovule

The bitegmic ovules are hemianatropous (Figs. 37, 39, 47–49) in *Aneilema scaberrimum, A. montanum, Murdannia divergens, Commelina attenuata* and *Streptalirion voluvile*; orthotropous (Fig. 46) in *Polia subumbellata* and orthotropous with a slight bend at the base in *Cyanotis* species (Figs. 33, 43). They are crassinucellate (Figs. 36, 39, 47, 48, 49) except in *Cyanotis* species (present study) and *Aneilema paniculatum* (Chikkannaiah, 1962) where they are tenuinucellate (Fig. 43).

The ovule primordium arises on the placenta as an outgrowth (Figs. 34, 40) and projects into the loculus (Fig. 31). The primordia of the integuments are initiated after the archesporium is differentiated in the ovule (Figs. 34, 35, 40, 41). In *Aneilema scaberrimum, A. montanum, Commelina attenuata, Murdannia divergens* and *Streptolirion volubile*, the ovules, during development, undergo curvature as a result the micropyle lies at right angles to the funiculus (Figs. 32, 34–39, 47, 48, 49). In the various species of *Cyanotis*, the pair of ovules in each loculus bend in opposite directions with the result one ovule faces upward and the other downward (Fig. 33). In *Pollia subumbellata* the ovules do not undergo any curvature during development (Figs. 44–46). The micropyle is formed by both the integuments (Figs. 39, 43, 46, 49) in *Pollia subumbellata, Cyanotis* species, *Aneilema montanum* and *Stroptolirion volubile*; it is zig-zag (Figs. 39, 49) in the two latter species. In

EXPLANATION TO FIGURES

Figs. 2–4, 6, 9, 22, 24, 28, 33, 43, 64–66, 68–70	*Cyanotis cucullata* ;
Figs. 5, 19, 40, 63	*C. axillaris* ;
Figs. 17, 41	*C. fasciculata* ;
Figs. 42, 67	*C. papilionacea* ;
Fig. 7	*C. tuberosa* ;
Figs. 10–15, 18, 21, 25, 32, 34–37, 50, 51, 53–55	*Aneilema scaberrimum*
Figs 23, 26, 27, 38, 39, 56, 57	*A. montanum* ;
Figs. 48, 61, 62	*Commelina attenuata* ;
Figs. 29, 52	*Murdannia nudiflora* ;
Fig. 47	*M. divergens* ;
Figs. 1, 20, 31, 44-46, 58, 59	*Pollia subumbellata* ;
Figs. 8, 16, 30, 49, 60	*Streptolirion volubile.*

Figs. 1–6 L.S. Young flower buds showing the organogeny of the various floral parts.

Figs. 7, 8 T.S. anther lobes showing epidermis, two wall layers, tapetum and sporogenous cells.

Figs. 9, 10 L.S. anther lobes showing epidermis, endothecium with thickenings and the uninucleate microspores surrounded by plasmodial tepetum.

Figs. 11–17 Stages in the meiosis of microsporocytes

Figs. 18–20 Isobilateral pollen tetrads.

Fig. 21 Decussate pollen tetrad.

Fig. 22 Uninucleate microspore.

Fig. 23 Nucleus of the microspore dividing.

Figs. 24–26 Formation of generative and vegetative cells.

Figs. 27–29 Pollen grains showing generative cell liberated into vegetative cytoplasm.

Fig. 30 Pollen grain showing the elongated generative cell and deformed vegetative cell.

Figs. 31, 32 T.S. Ovaries showing the orientation of ovules.

Fig. 33 L.S. half ovary showing two ovules with micropyles facing opposite directions.

Figs. 34–49, 59, 66 Stages in the development of ovule.

Figs. 50, 63 L.S. nucelli at the archesporial stage.

Figs. 51, 64 L.S. nucelli showing megaspore mother cells with two parietal layers in Fig. 51 and no parietal layer in Fig. 64.

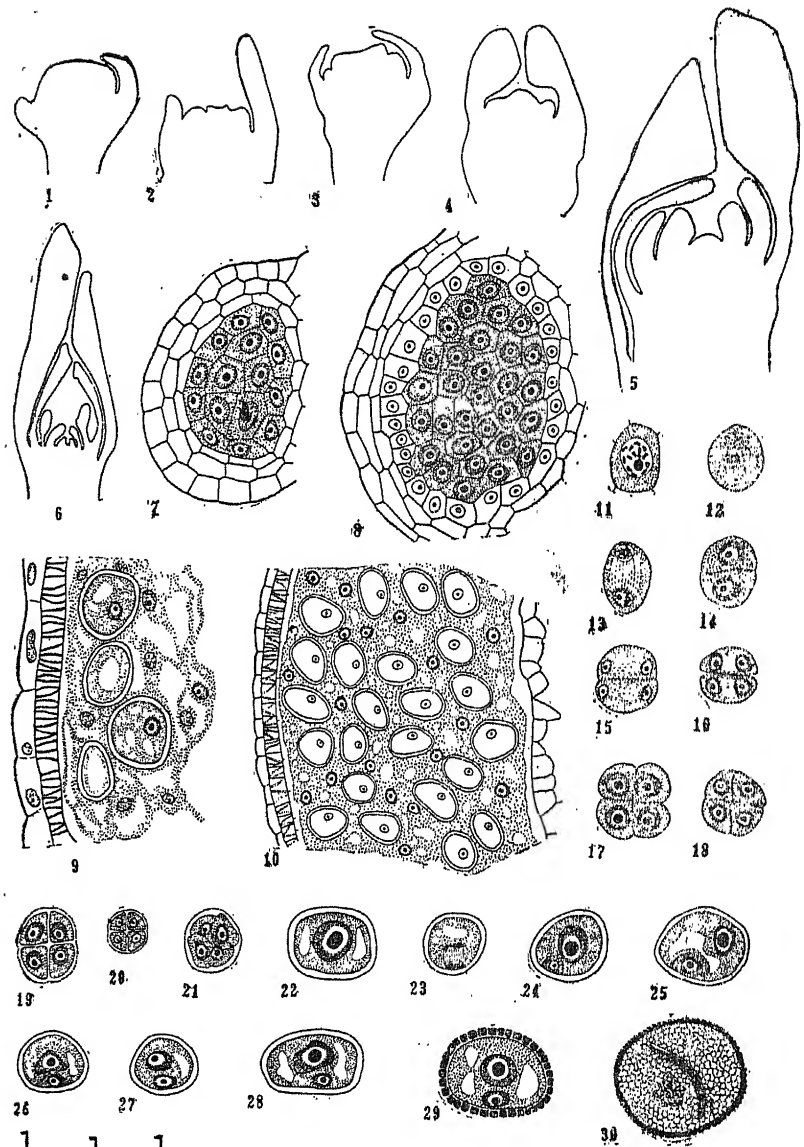
Figs. 52, 65 L.S. nucelli showing dividing megasporocyte with one parietal layer in Fig. 52 and no parietal layer in Fig. 65.

Figs. 53, 56, 58, 67 L.S. nucelli showing linear megaspore tetrads. Note the three upper cells degenerating in Fig. 67.

Figs. 54, 61 Four and two nucleate embryo sacs.

Fig. 62 8-nucleate embryo sac showing the differentiation of antipodal cells.

Figs. 55, 57, 60, 62, 68, 69, 70 Organised embryo sacs. Note starch grains in Figs. 57, 60, 69, 70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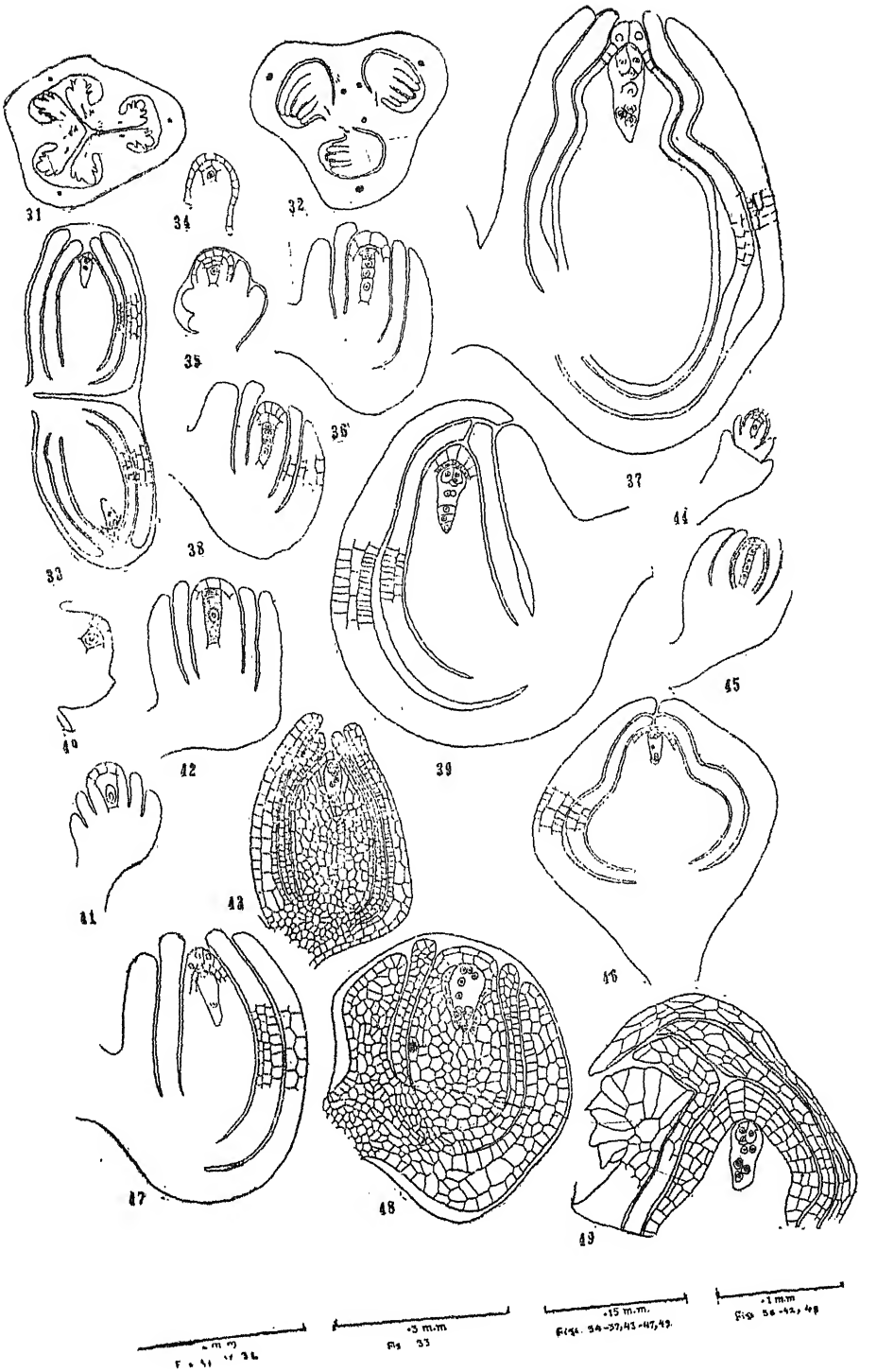
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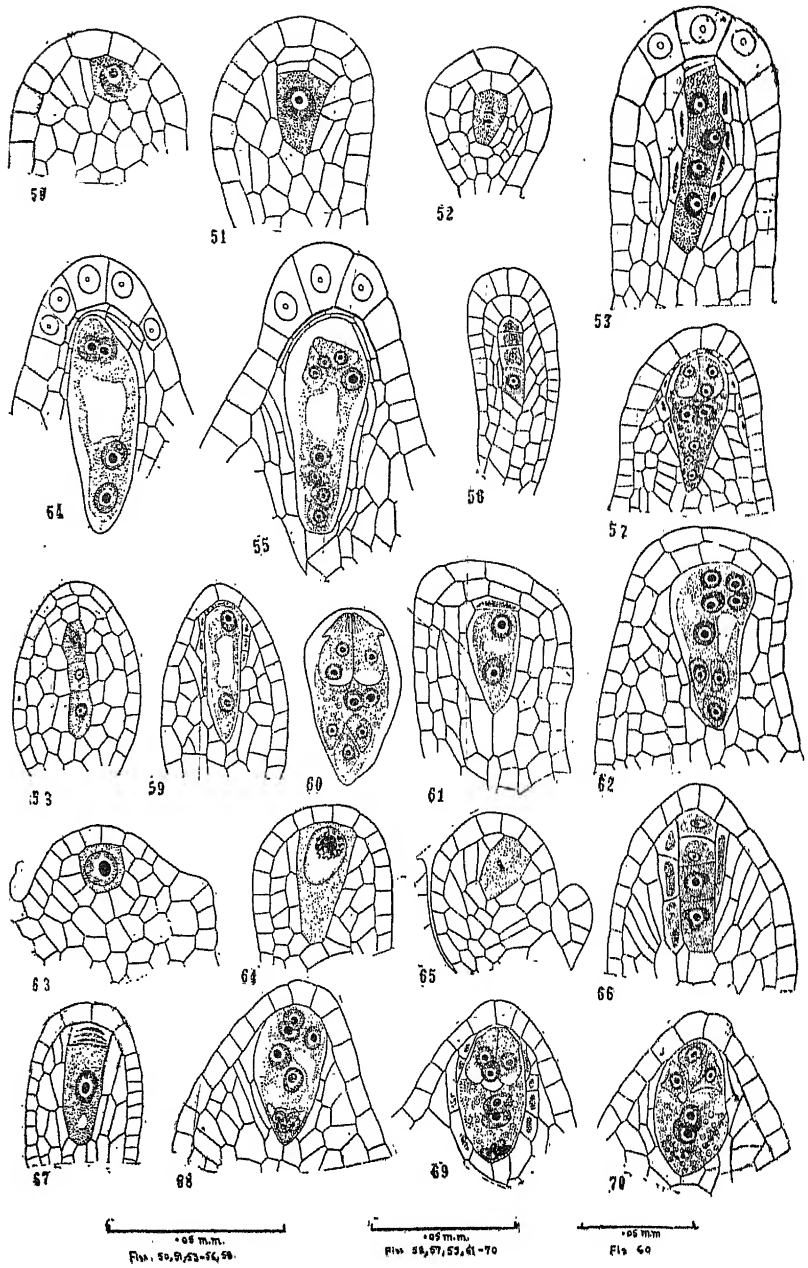

Figs. 50, 51, 53-54, 58.

Figs 58, 67, 53, 61-70

Fig 60

Aneilema scaberrimum and *Murdannia divergens* the inner integument extends only slightly beyond the nucellus to form a wide micropyle (Figs. 37, 47). In *Commelina attenuata* the integuments just reach the height of the nucellus as a result the upper part of the nucellus is uncovered (Fig. 48). Absence of micropyle is also reported in *Floscopa scandens, Commelina subulata Aneilema paniculatum* (Chikkannaiah, 1962), *Rhoec discolor* (Chikkannaiah, 1961) and *Murdannia simplex* (Chikkannaiah, 1964). The cells of the nucellar epidermis in the region of the micropyle are prominently enlarged and constitute the epistase (Figs. 37 47, 53–55) except in *Commelina attenuata, Cyanotis* species and *Pollia subumbellata.* In *Streptolirion volubile,* the cells of the nucellar epidermis undergo periclinal divisions to form a nucellar cap consisting of four to six layers (Fig. 49). A primary parietal cell is cut off in all the taxa (Fig. 34) except in *Cyanotis* species (Figs. 40–42) and it gives rise to 1 or 2 parietal layers (Figs. 35, 36, 44, 45, 47, 48). A noteworthy feature in the ovules is the constriction of the nucellus towards the micropylar end. The integuments also follow the contour of the nucellus (Figs. 37, 46, 49). The embryo sac lies above the constriction (Figs. 37, 46, 49). The outer integument is 2–layered in *Murdannia aivergens* (Fig. 47) while in others it is 3-layered (Figs. 33, 39, 43, 46, 49) ; in *Commelina attenuata* it is 4-layered (Fig. 48). The inner integument is 2-layered in all the investigated species (Figs. 33, 39, 43, 46, 48, 49) except in *Murdannia divergens* where it is 3-layered. (Fig. 47).

Megasporogenesis and female gametophyte

The nucellus in early stages consists of a homogeneous mass of parenchymatous cells. A hypodermal cell becomes more conspicuous than the rest by its large size, dense cytoplasm and prominent nucleus ; this functions as the female archesporium (Fig. 50). In *Cyanotis* species the hypodermal archesporium directly functions as megaspore mother cell without cutting off a parietal cell (Figs. 63, 64). In others the archesporial cell divides periclinally into an outer parietal cell and an inner megaspore mother cell (Figs. 51, 52). The parietal tissue is 1-layered in *Aneilema montanum, Commelina attenuata* and *Murdannia nudiflora* (Figs. 47, 56, 57, 61, 62) and 2-layered in *Aneilema scaberrimum* (Figs. 53–55). The megaspore mother cell undergoes meiosis (Fig. 65) and the resulting tetrads are linear (Figs. 53, 56, 58, 66, 67). The chalazal megaspore is functional (Fig. 67) and as a result of three successive free nuclear divisions it gives rise to an octonucleate embryo sac (Figs. 54, 55, 57, 59, 62, 67, 68). Thus, the development of the embryo sac follows the Polygonum type. The antipodals are organised as definite cells before the organisation of egg apparatus (Figs. 62, 68) and are ephemeral (Figs. 69, 70). The embryo sac enlarges during development and crushes the parietal cells above and some of the nucellar cells on the sides and below it (Fig. 57). The egg apparatus consists of two synergids, which show prominent hooks, filiform apparatus and basal vacuoles, and an egg (Fig. 60). The polar nuclei fuse before fertilization (Fig. 57, 60, 69, 70) and the secondary nucleus lies near the egg apparatus. Starch grains are present in the embryo sac at maturity (Figs. 57, 60, 69, 70).

Summary and Conclusions

Members of Commelinaceae exhibit a uniformity in their embryological features.

The floral parts originate in acropetal succession. The anther wall comprises of epidermis, endothecium with thickenings, a middle layer and a plasmodial tapetum. The plasmodial anther tapetum, successive type of division of pollen mother cells, isobilateral pollen tetrads ; 2-celled, monocolpate pollen grains and

the elongated generative cell seem to be common to all the investigated taxa of the family (Maheshwari and Baldev, 1958 ; Chikkannaiah, 1961, 1962, 1963, 1964, 1965 ; present study).

Although, the ovules in the family are described as orthotropous in most of the taxonomic books (Lawrence, 1951 ; Rendle, 1952 ; Hutchinson, 1959), there seem to be at least two main types of ovules prevalent in the family *viz.*, hemianatropous and orthotropous. Among the members investigated presently they are hemianatropous in *Aneilema scaberrimum*, *A. montanum*, *Murdannia divergens*, *Commelina attenuata* and *Streptolirion volubile* ; *orthotropous in Pollia subumbellata* and *Cyanotis* species. In the last genus the two ovules in each loculus bend in opposite directions as a result the upper ovule has the micropyle facing upwards while the lower has a downwardly pointing micropyle. They are crassinucellate except in *Cyanotis* species, where only tenuinucellate ovules are met with.

The hypodermal archesporium functions as megaspore mother cell after cutting of a primary parietal cell, except in *Cyanotis* species where it directly functions as megaspore mother cell. The megaspore tetrads are linear. The embryo sac development in all the species under present study follows the Polygonum type. The antipodals are ephemeral, and the polar nuclei fuse before fertilization.

Rao and Kammathy (1966) separated the two species of *Cyanotis* viz., *C., axillaris* and *C. cucullata* from *Cyanotis* proper and created a new genus *Amischophacelus* Rolla Rao et Kammathy gen. nov. with the above two species on the basis of some morphological and cytological grounds. The present study shows that *C. axillaris* and *C. cucullata* resemble other species of the genus in the tenuinucellate condition of the ovules and their orientation in each loculus, one facing upwards and the other downwards. Thus the present study does not support the creation of a new genus *Amischophacelus* with the two species of *Cyanotis* viz., *C. axillaris* and *C. cucullata.*

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Effect of Plant-Age on Rhizosphere Micro-fungi*

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Introduction

Timonin (1940) observed that the rhizosphere effect increased with the age of the plants and normally reached its maximum at the stage of greatest vegetative growth. Following the death of the plant, the microbial population reverted gradually to the level of that in the surrounding soil.

Katznelson (1946) remarked, "It is clear that the rhizosphere is unique environment exerting on many groups and species of soil organisms a powerful selective action which varies with the type, age, nature and vigour of a plant, treatment and moisture content of soil. The soil factors may exert their influence directly by stimulating or retarding plant development."

Starkey (1929), *a, b, c* : 31, *a, b,*) concluded that microbial activity was the greatest at periods of advanced vegetative or fruiting of the plant. Similar views are also put forward by Ivarson and Katznelson (1960).

To study the effect of the age of the surface vegetation on the nature and population of miro-organisms, two leguminous plants, viz. *Lens esculenta* Moench. Meth. and *Cicer arietinum* Linn. were selected. Four plots, I and II cultivated fields in which the respective crops being sown for the last few year ; and III and IV, experimental plots prepared in pasture lands without cultivation, were selected in each case.

Materials and Methods

For the study of the rhizosphere fungal population, the plants from the above plots were taken out carefully with a sterilized spatula at the intervals of 15 days from the seedling stage (when the plants were 15 days old) to the senescent stage. Care was taken to take out, as far as possible, the whole root-system from the soil. The roots where cut off with a pair of sterilized scissors and the extra soil particles attached to them were removed by giving them a gentle shake. These roots were put into sterilized 250 cc. conical flasks containing 200 cc of sterilized water. The flasks were shaken vigorously to make a homogeneous suspension of the rhizosphere soil. 1 cc. of the soil solution was poured in 10 sterilized Petridishes. To these Petridishes was added about 2 cc. of the melted and cooled agar medium of the following composition which is usually used in this laboratory and has been found to give satisfactory growth.

Dextrose, 10 g. ; peptone, 5 g. ; KH_2PO_4, 1 g. ; $MgSO_4$, $7H_2O$, 0·5 g. ; agar, 20 g. ; distilled water, 1 litre and Rose-Bengal 1:15,000.

Plates were incubated for 5-6 days at 25°C and the fungal population was recorded. The soil solution left after the inoculation was dried and finally weighed to determine the fungal population per gm. of oven-dried soil.

*Part of thesis approved for award of Ph.D degree of Banaras Hindu University.

The frequency of the fungal species was recorded from the population of 10 Petri-plates. Each Petri-plate was considered a unit of study just like a quadrat in the phytosociological study of higher plants. The expression of classes of frequency is, as suggested by Saksena (1955).

Discussion and Interpretation of Data

From the data tabulated above, it may be observed that frequently the lowest number of micro-organism was isolated from the rhizosphere when the plants were 15 days old. The lowest number may be due to (*i*) the limited root-surface being available for colonization by micro-organism and (*ii*) the secretion of a smaller amount of root exudate. With the increasing age of the plants, the fungal population showed a continuous increase and reached the maximum when the plants were in the flowering stage (Plate 1-IV). This increase may be due to the fact that plants at maturity provide a greater surface area of the root for colonization by the microbes and also secrete the maximum amount of root-exudate. The rise in the nutritional level of the environment surrounding the root surface encouraged a higher fungal population. There was a fall in the micro-fungal flora after this peak was reached but with a second rise in number when roots were decaying. The old roots with dead and sloughed-off tissue contribute appreciably to the microbiological composition and the readily available carbohydrates are quickly metabolized by the saprophytic bacterial and fungal species. These activities result in increasing the microbial number in the end.

Garrett (1951) arranged the fungal species with regard to their colonizing power in the sequence of Phycomycetes, Ascomycetes, Basidiomycetes and Deutero-mycetes. The findings of the author confirm the preceding sequence even with regard to saprophytic fungi. The phycomycetous species were primary dominant colonizers in the early stage of the plant growth. Their frequency decreased continuously with the advancing age of the plant. (Tables I-VIII). It is evident that till maturity the fungal population is dominated by species of Mucorales. This observation is in conformity with that of others. Chesters and Parkinson (1959) remarked, "the inability of species of this group to utilize complex carbohydrate and the fact that they exhibit rapid growth on sugars and inorganic sources of nitrogen may condition their disappearance, as regions of root-tissues age and sloughoff cellulosic superficial tissue." Peterson (1958) also noted that *Penicillium* and certain species of Mucorales were relatively more abundant on the root-surface of wheat and in the rhizosphere at the seedling stage than at a later stage of growth.

Ascomycetous forms were rare in their occurrence and, whenever present, were generally with low frequency. Basidiomycetous forms were absent.

Majority of species isolated from the rhizosphere of both the legumes belonged to Deuteromycetes, members of which are pronounced cellulose decomposers. A few forms, viz. *Aspergilli, Penicillia, Paecilomyces fusisporus, Trichoderma viride, Alternaria, Curvularia, Cladosporium herbarum* and *Fusaria* were frequently isolated with higher frequency. Dematiaceous forms were dominant in the later stage of the plants (Tables I-VIII) when the moisture content of the soil was low and temperature was high (author's observation). The dominance of dark-coloured froms in soil with low moisture content and high temperature was also suggested by Durrel and Shield (1960), Nicot (1960) and Mishra (1964)

TABLE I

Frequency of the fungal species in Lens esculenta *plots (cultivated)*

(25th Nov., 1963—25th March, 1964)

Fungi/plots	Nov. 25		Dec. 10		Dec. 25		Jan. 10		Jan. 25		Feb. 10		Feb. 25		Mar. 10		Mar 25	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Mucor luteus Linn.	–	–	3	–	–	1	–	–	–	4	–	–	–	–	1	–		
M. hiemalis Wehmer	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		
Absidia sp.	–	–	2	–	1	–	1	–	–	–	–	–	–	1	–	–		
Rhizopus nigricans Ehrenberg	3	5	2	5	–	5	–	2	2	–	–	–	–	–	1	1		
Phycomycetous sterile colonies	–	–	–	–	–	–	–	–	1	–	–	–	2	–	1	1		
Choanephora cucurbitarum (Berkley and Ravenel) Thaxter	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–		
Cunninghamella blakesleeana Lendner	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–		
Syncephalastrum racemosum (Cohn) Schroeter	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–		
Aspergillus nidulans (Eidam) Wint	2	–	1	–	1	–	–	–	–	1	–	–	–	–	–	–		
Chaetomium globosum Kunze	1	–	–	–	–	–	–	–	–	–	–	–	–		–	–		
Aspergillus niger Van Tiegham	–	3	–	–	–	1	–	1	5	–	5	5	1	5	4	3		
A. terreus Thom	3	2	–	1	3	1	5	5	5	–	5	2	5	–	3	1		
A. flavus Link	–	2	–	5	–	5	–	5	1	–	–	–	–	1	1	2		
A. candidus Link	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–		
A. sydowi (Bain. and Sar.) Thom and Church	–	2	–	–	–	–	–	1	–	–	–	–	–	–	–	–		
A. sulphureus (Fres.) Thom and Church	–	2	–	–	–	–	–	1	–	–	–	–	–	–	–	–		
A. japonicus Saito	–	–	–	–	–	–	1	–	–	–	2	–	–	–	–	–		
Penicillium humicola Oud.	5	2	–	–	5	–	5	1	2	3	5	2	–	–	–	–		

P. notatum Westling	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	
P. funiculosum Thom	–	–	–	–	2	–	5	1	4	–	1	–	–	–	–	–	
P. purpurogenum Stoll	–	–	4	–	3	–	-	–	–	–	2	–	1	–	3	–	
P. rubrum Stoll	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	
P. restrictum Gilman and Abbott	–	–	–	–	–	1	–	–	1	–	–	–	–	–	–	–	
Paecilomyces fusisporus Saks.	1	2	–	1	–	1	–	–	1	–	–	–	–	–	–	2	
Cephalosporium coremioides Raillo	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	
Curvularia lunata (Walker) Boedijn	–	–	–	2	–	2	2	–	3	–	3	3	4	–	4	5	
C. tuberculata Jain	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	
Cladosporium herbarum (Pers.) Link	–	–	–	1	1	1	–	–	1	–	2	–	4	–	–	4	
Alternaria tenuis Nees.	–	–	–	2	–	–	–	–	–	1	3	–	4	1	–	–	
A. humicola Oud.	–	–	–	–	–	1	–	–	3	–	–	–	-	–	3	2	
Humicola fusco-atra Traaen	–	–	–	–	–	–	-	–	–	–	-	–	2	2	–	2	
Helminthosporium anomalum Gilman and Abbott	–	–	–	–	–	–	3	–	–	1	–	–	–	–	–	–	
H. flagelloideum Atkinson	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Papulospora sp.	–	–	–	–	–	–	–	1	–	–	–	–	–	1	–	–	
Fusarium nivale (Fries) Cesati	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5.	5	
F. oxysporum Schlechtendahl	–	–	–	2	–	2	–	–	–	–	–	–	–	–	–	–	
F. roseum (LK.) emend	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	–	
Sclerotium sp.	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	
Dark sterile colonies	–	–	–	–	–	–	1	–	–	–	1	–	–	–	3	2	

TABLE II

Frequency of the fungal species in Lens esculenta *plots (experimental)*

(25th Nov., 1963—25th March, 1964)

Fungi/plots	Nov. 25		Dec. 10		Dec. 25		Jan. 10		Jan. 25		Feb. 10		Feb. 25		Mar. 10		Mar. 25	
	III	IV	III	IV	III	IV	III	IV	III	IV	III	IV	III	IV	III	IV	III	IV
Mucor luteus Linn	5	4	4	5	4	4	5	3	4	5	2	3	2	2	2	1	1	1
Rhizopus nigricans Ehrenberg	–	5	4	4	5	4	3	–	2	3	–	2	1	2	1	–	1	1
Phycomycetous sterile colony	–	2	–	3	2	–	–	–	–	–	–	–	1	–	1	–	–	–
Choanephora cucurbitarum (Berkley and Ravenel) Thaxter	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1	2	–	–
Cunninghamella blakesleeana Lendner	–	–	–	–	2	–	–	–	1	1	3	4	1	2	1	1	1	–
Thielavia terricola (Gilman and Abbott) Emmons	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–
Chaetomium globosum Kunze	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–
Aspergillus nidulans (Eidam) Wint	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	2
Phoma hibernica Grimes O'Connor and Cummins	–	–	–	–	–	1	–	–	–	–	2	1	–	–	–	3	–	1
Trichoderma viride Pers. exFr	–	2	1	–	–	1	–	–	–	–	–	–	–	–	–	5	–	–
Aspergillus niger Van Tiegham	5	–	1	–	4	2	1	2	–	–	–	–	–	1	3	3	1	4
A. terreus Thom	–	–	–	1	–	–	–	3	–	–	–	–	2	–	3	5	4	5
A. flavus Link	1	–	1	4	–	2	1	3	–	–	–	–	3	3	2	3	1	3
A. candidus Link	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	3	–	–
Penicillium humicola Oud.	2	–	–	–	3	5	3	1	–	–	–	–	–	–	2	3	4	2

P. notatum Westling	1	–	–	–	–	–	–	1	–	–	–	–	–	–	1	3	3	4
P. funiculosum Thom	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–
P. purpurogenum Stoll	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	1	–	–
Paecilomyces fusisporus Saks.	–	–	2	–	–	–	–	–	–	–	–	–	–	2	5	1	3	–
Curvularia lunata (Walker) Boedijn	1	–	1	–	2	–	–	2	2	–	3	1	3	4	3	4	4	5
C. tuberculata Jain	–	–	–	–	–	–	–	–	3	1	–	–	–	–	–	–	–	–
Cladosporium herbarum (Pers.) Link	–	–	1	1	2	1	–	–	3	–	3	1	2	1	4	3	4	3
Alternaria tenuis Nees.	–	–	–	–	–	–	–	–	2	–	2	–	3	–	–	–	–	–
A. humicola Oud.	–	–	–	–	–	–	–	1	–	–	–	–	–	–	4	3	3	–
Humicola fusco-atra Traaen	–	–	–	–	–	–	–	–	2	–	–	–	1	–	–	2	–	–
Helminthosporium anomalum Gilman and Abbott	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	4	3	–
Papulospora sp.	–	–	–	–	–	–	–	–	–		–	–	–	–	–	–	–	2
Fusarium nivale (Fries) Cesati	5	5	–	5	5	5	–	5	5	5	4	5	5	5	5	5	5	5
F. oxysporum Schlechtendahl	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–
Sclerotium sp.	–	–	–	–	–	–	1	–	3	3	3	1	–	–	–	–	–	–
Black sterile colony	–	–	–	–	–	1	1	–	–	–	–	1	–	–	–	1	–	–

TABLE III

Frequency of fungal species in Lens esculenta *plots (cultivated)*

(25th Nov., 1964 to 28th Feb., 1965)

Fungi/plots	Nov. 15		Nov. 30		Dec. 15		Dec. 30		Jan. 15		Jan. 30		Feb. 15		Feb. 2	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Mucor luteus Linn.	–	–	–	–	–	–	–	2	–	1	–	–	–	–	–	–
M. hiemalis Wehmer	3	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Absidia sp.	–	–	–	–	–	1	–	1	–	1	–	2	–	–	–	–
Rhizopus nigricans Ehrenberg	3	4	–	4	–	–	–	2	–	1	–	1	3	2	–	1
Phycomycetous sterile colonies	–	–	–	2	–	1	1	1	–	1	–	–	–	–	–	–
Cunninghamella blakesleeana Lendner	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–
. echinulata Thaxter	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–
Syncephalastrum racemosum (Cohn) Schroeter	–	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–
Gymnoascus sp.	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Thielavia terricola (Gilman and Abbott) Emmons	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetomium terrestre Dwivedi	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Neocosmospora vasinfecta E. F. Smith	2	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Aspergillus nidulans (Eidam) Wint.	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Botryodiplodia sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Phoma hibernica Grimes, O'Connor and Cummins	–	1	–	1	–	–	–	–	–	1	–	–	–	–	–	–
Trichoderma viride Pers. exFr.	–	–	–	–	–	–	2	–	–	–	–	1	–	–	–	1
Aspergillus niger Van Tiegham	–	1	–	2	2	5	–	5	1	1	3	1	–	1	–	1
A. terreus Thom	4	–	–	2	–	3	3	–	–	2	2	–	–	2	–	4

A. Flavus Link	–	1	1	–	1	1	1	1	1	3	1	3	2	2	–	1
A. candidus Link	–	–	1	1	1	1	–	1	–	1	–	–	–	–	–	1
A. Sydowi (Bain. and Sar.) Thom and Church	–	2	–	–	–	1	–	–	3	–	–	–	–	–	–	–
A. sulphureus (Fres.) Thom and Church	–	–	–	1	–	–	–	–	–	–	–	–	–	1	–	–
Penicillium humicola Oud.	–	1	–	1	–	–	–	–	–	–	–	1	3	–	–	1
P. notatum Westling	–	–	1	–	1	2	–	1	1	–	3	2	–	2	–	–
P. funiculosum Thom	–	–	–	1	–	–	–	–	1	–	4	5	–	1	–	–
P. purpurogenum Stoll	–	–	–	–	–	1	–	1	–	1	–	1	–	–	–	–
P. rubrum Stoll	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
Paecilomyces fusisporus Saks.	4	–	1	4	3	1	–	1	–	3	–	1	–	1	3	2
P. varioti Bainier	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–
Fusidium sp.	–	2	–	–	–	–	–	–	–	–	–	–	–	1	1	–
Cephalosporium coremioides Raillo	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
C. asperum Marchal	1	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–
Monilia geophila Oud.	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Curvularia lunata (Walker) Boedijn	–	3	–	1	2	1	1	3	3	3	4	–	4	3	–	–
C. geniculata (Tracy and Earle) Boedijn	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Cladosporium herbarum (Pers.) Link	–	1	4	3	2	3	4	3	–	2	3	3	–	3	3	2
Alternaria tenuis Nees.	–	–	–	–	–	–	–	1	2	1	2	1	–	–	3	3
Humicola fusco-atra Traaen	–	–	–	–	–	–	–	–	–	2	–	1	–	–	–	3
Helminthosporium anomalum (Gilman and Abbott)	–	–	–	1	–	1	–	1	–	–	–	1	–	–	–	–
Papulospora sp.	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	2
Fusarium tricinctum (Cda.) emend.	5	1	5	5	5	5	5	4	4	5	2	4	3	–	5	5
F. roseum (LK.) emend.	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–
Myrothecium verrucaria (Albertini and Schweinitz) Ditmar	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1
Sclerotium sp.	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Dark sterile colonies	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–

TABLE IV

Frequency of fungal species in Lens eseulenta *plots (experimental)*

(15th Nov., 1964 to 30th March, 1965

Fungi/plots	Nov. 15		Nov. 30		Dec. 15		Dec. 30		Jan. 15		Jan. 30		Feb. 15		Feb. 28		Mar. 15		Mar. 30	
	III	IV	III	IV	III	IV	III	IV	III	IV	III	IV	III	IV	III	IV	III	IV	III	IV
Mucor luteus Linn.	–	–	–	2	2	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
M. hiemalis Wehmer	2	–	2	2	2	3	–	1	–	–	–	–	–	2	–	–	–	–	–	–
Absidia sp.	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–
Rhizopus nigricans Ehrenberg	–	–	–	–	5	–	1	1	–	1	2	2	2	1	1	2	2	1	2	–
R. oryzae Went and Gerling	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Phycomycetous sterile colony	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Zygorhynchus sp.	–	–	–	–	–	–	–	1	–	3	–	–	–	–	–	–	–	–	–	–
Choanephora cucurbitarum (Berkley and Ravenel) Thaxter	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Cunninghamella blakesleeana Lendner	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Syncephalastrum racemosum (Cohn) Schroeter	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Gymnoascus sp.	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thielavia terricola (Gilman and Abbott) Emmons	1	1	–	1	–	–	–	–	–	–	–	1	–	–	–	–	–	–	1	–
Aspergillus nidulans (Eidam) Wint.	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Phoma hibernica Grimes, O'Connor and Cummins	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1
Trichoderma viride Pers. exFr.	1	1	1	1	–	1	1	–	–	–	–	–	1	1	–	–	–	–	2	1
Aspergillus niger Van Tiegham	5	4	1	4	4	3	1	2	2	1	1	1	–	1	5	4	2	–	4	4
A. terreus Thom	–	1	–	1	–	1	–	1	–	2	1	–	2	–	–	–	3	5	2	3
A. flavus Link	–	5	1	5	4	5	–	1	3	3	5	1	5	5	5	1	4	1	5	4

A. candidus Link	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–	–	1	1	1
A. sydowi (Bain and Sar.) Thom and Church	–	1	–	–	–	–	1	1	–	1	–	–	–	–	–	–	–	–	2	1
Penicillium humicola Oud.	–	5	5	–	1	2	3	1	5	5	–	2	–	–	–	–	4	1	–	–
P. notatum Westling	1	–	–	–	–	–	1	1	–	1	–	1	–	1	1	–	–	–	1	1
P. funiculosum Thom	–	–	–	–	–	–	–	–	1	–	5	2	2	5	–	–	–	–	–	2
Paecilomyces fusisporus Stoll	2	–	1	2	–	2	1	1	1	1	–	1	–	–	–	–	2	1	1	–
Cephalosporium coremioides Raillo	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Gliocladium fimbriatum Gilman and Abbott	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Curvularia lunata (Walker) Boedijn	–	–	1	1	2	–	1	1	–	–	4	–	4	–	–	–	–	–	4	4
Cladosporium herbarum (Pers.) Link.	–	–	–	–	1	3	3	5	2	1	3	3	–	2	–	1	–	–	3	3
Alternaria tenuis Nees	–	–	–	–	–	–	–	–	–	–	–	–	2	2	2	1	–	–	3	1
A. humicola Oud.	–	–	–	–	–	–	1	–	2	–	–	1	–	–	–	–	–	–	–	–
Humicola fusco-atra Traaen	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Helminthosporium anomalum Gilman and Abbott	–	1	–	–	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–
Papulospora sp.	–	1	–	–	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–
Fusarium tricinctum (Cda.) emend.	5	5	3	–	5	5	5	5	–	5	2	5	3	5	5	5	5	5	5	5
Fusarium roseum (LK.) emend.	–	1	–	5	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	5
Myrothecium verrucaria (Albertini and Schweinitz) Ditmar	–	–	–	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–	–	–
Hormiscium sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Black sterile colony	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	1

TABLE V

Frequency of fungal species in Cicer arietinum *plots (cultivated)*
(1st November, 1963 – 15th March, 1964)

Fungi/plots	Nov. 1		Nov. 15		Dec. 1		Dec. 15		Jan. 1		Jan. 15		Feb. 1		Feb. 15		Mar. 1		Mar. 15	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Mucor luteus Linn.	–	–	–	–	–	–	3	2	–	1	–	–	2	–	–	–	–	–	–	–
M. hiemalis Wehmer	4	5	5	4	5	5	–	–	–	–	1	1	–	1	–	1	1	1	1	1
Rhizopus nigricans Ehrenberg	5	3	2	5	4	5	3	–	2	1	2	–	1	1	–	1	1	1	1	–
Phycomycetous sterile colony	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	1	–	1	–	–
Zygorhynchus sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–
Choanephora cucurbitarum (Berkley and Ravenel) Thaxter	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
Cunninghamella blakesleeana Lendner	–	–	2	–	–	–	–	–	–	–	2	1	–	–	–	–	–	1	–	–
Ph ma hibernica Grimes, O'Connor and Cummins	–	–	–	1	1	–	–	1	1	1	–	–	–	–	–	–	–	–	2	–
Trichoderma viride Pers. exFr.	2	1	2	3	–	–	2	–	–	2	–	2	–	–	–	–	–	–	–	–
Aspergillus niger Van Tiegham	–	2	3	5	5	3	5	5	5	5	3	5	4	5	3	5	5	5	5	5
A. terreus Thom	–	3	–	–	5	–	3	–	–	5	1	1	3	3	2	3	2	5	5	5
A. flavus Link	4	1	2	5	2	5	5	–	–	–	5	1	5	1	1	–	3	1	3	5
A. candidus Link	–	–	–	–	–	–	1	–	–	–	1	1	–	1	–	–	–	–	–	–
A. sydowi (Bain. and Sar.) Thom and Church.	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–
Penicillium humicola Oud.	–	–	3	–	–	–	4	–	2	1	4	1	4	4	–	–	5	5	5	4

P. notatum Westling	–	–	–	–	5	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–
P. funiculosum Thom	1	–	–	–	–	–	4	–	–	–	2	1	1	–	3	–	–	–	–	–
Paecilomyces fusisporus Saks.	1	2	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1
Cephalosporium coremioides Raillo.	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Gliocladium roseum (Link) Thom	–	–	–	–	–	–	–	3	5	3	–	–	–	–	–	3	–	3	1	4
Curvularia lunata (Walker) Boedijn	1	–	1	3	1	1	2	–	4	–	–	4	4	–	–	4	2	1	4	–
Alternaria tenuis Nees.	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–
A. humicola Oud.	–	–	–	–	–	–	–	–	3	1	–	–	–	–	3	2	5	2	5	–
Cladosporium herbarum (Pers.) Link	–	–	1	–	–	–	–	5	5	5	2	1	3	3	4	2	4	–	–	2
Hormodendron sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–
Papulospora sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2
Humicola fusco-atra Traaen	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	1	–	–
Helminthosporium anomalum Gilman and Abbott	–	–	–	–	–	–	–	–	–	–	1	1	–	–	1	1	–	–	–	–
Fumago sp.	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–
Fusarium nivale (Fries) Cesati	4	2	5	5	5	5	5	5	5	5	5	5	5	5	3	5	5	5	5	5
F. Oxysporum Schlechtendahl	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
F. roseum (LK.) emend	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Black sterile colony	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1

TABLE VI

Frequency of the Fungal species in Cicer arietinum *plots (experimental)*

(1st November, 1963 – 1st March, 1964)

Fungi/plots	Nov. 1		Nov. 15		Dec. 1		Dec. 15		Jan. 1		Jan. 15		Feb. 1		Feb. 15		Mar. 1	
	III	IV	III	IV	III	IV	III	IV	III	IV	III	IV	III	IV	III	IV	III	IV
Mucor luteus Linn.	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–
M. hiemalis Wehmer	5	4	4	5	3	4	3	–	3	2	2	2	–	–	1	1	1	1
Rhizopus nigricans Ehrenberg	–	5	–	4	4	–	2	4	2	1	1	1	1	1	–	1	1	1
Phycomycetous sterile colony	–	1	–	3	–	–	–	–	2	–	–	2	1	1	1	–	–	1
Zygorhynchus sp.	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Choanephora cucurbitarum (Berkley and Ravenel) Thaxter	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cunninghamella blakesleeana Lendner	3	–	3	–	–	2	1	–	–	2	1	1	–	1	1	–	–	–
Aspergillus nidulans (Eidam) Wint	–	–	–	1	–	–	–	–	–	–	1	–	–	1	–	–	–	–
Phoma hibernica Grimes O'Connor and Cummins.	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–
Trichoderma viride Pers. exFr.	1	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Aspergrillus niger Van Tiegham	2	2	1	2	1	–	4	2	4	–	2	–	4	–	4	3	5	4
A. terreus Thom.	–	–	1	–	–	–	2	–	–	–	1	4	4	1	3	5	3	5
A. flavus Link	2	2	–	3	1	–	3	1	4	4	–	–	3	1	3	–	3	3
A. candidus Link.	–	–	2	–	–	–	–	–	–	1	–	–	–	–	–	1	–	–
A. sydowi (Bain. and Sar.) Thom and Church	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–

A. sulphureus (Fres.) Thom and Church	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–
Penicillium humicola Oud.	3	3	5	4	5	5	5	5	–	4	5	5	–	5	5	5	5	3
P. funiculosum Thom	2	–	2	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
P. purpurogenum Stoll	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	–	–	–
Paecilomyces fusisporus Saks.	–	–	–	3	2	–	–	–	–	–	–	–	1	–	–	–	–	–
Curvularia lunata (Walker) Boedijn	1	–	1	–	1	–	2	2	5	5	3	3	4	4	5	2	3	4
Alternaria tenuis Nees.	–	–	–	–	–	–	–	–	3	2	–	–	4	–	–	–	–	–
A. humicola Oud.	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	3	–	–
Cladosporium herbarum (Pers.) Link	1	–	1	–	1	–	2	2	–	–	4	–	3	–	4	–	–	–
Papulospora sp.	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Humicola fusco-atra Traaen	–	–	–	–	–	–	–	–	2	–	–	–	–	1	–	–	–	2
Helminthosporium anomalum Gilman and Abbott	–	1	–	1	–	–	2	1	–	–	–	–	–	–	–	–	–	–
Fumago sp.	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–
Fusarium nivale (Fries) Cesati	4	–	5	–	–	5	–	–	4	5	5	4	5	5	5	5	5	5
F. oxysporum Schlechtendahl	–	–	–	1	–	–	5	5	–	–	–	–	–	–	–	–	–	–
Sclerotium sp.	–	–	–	–	–	2	–	–	–	–	1	–	–	–	–	1	–	–
Dark sterile colonies	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–

TABLE VII

Frequency of Fungal species in Cicer arietinum *plots (cultivated)*

(10th November, 1964 to 25th November, 1965)

Fungi/plots	Nov. 10		Nov. 24		Dec. 10		Dec. 25		Jan. 10		Jan. 25		Feb. 10		Feb. 25		Mar. 10		Mar. 25	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Mucor luteus Linn.	–	–	–	–	–	–	–	–	–	1	–	2	–	–	–	–	–	1	–	2
M. hiemalis Wehmer	5	5	3	4	4	3	4	2	3	–	1	–	2	1	–	–	–	–	2	–
M. plumbeus Bonorden	–	–	–	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rhizopus nigricans Ehrenberg	2	5	–	–	5	4	5	2	3	5	2	2	1	1	2	2	2	2	1	2
Choanephora cucurbitarum (Berkley and Ravenel) Thaxter	–	1	–	–	–	–	1	–	2	–	–	–	1	3	–	–	–	–	1	–
Syncephalastrum racemosum (Cohn.) Schroeter	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–
Aspergillus terreus Thom	–	–	–	4	–	1	–	–	–	2	–	–	–	5	–	1	1	–	5	1
A. flavus Link	5	5	5	–	4	–	1	3	4	5	3	4	4	2	5	2	5	1	1	5
A. candidus Link	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–	–
A. Sydowi (Bain. and Sar.) Thom and Church	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	–	–	–	–	–
A. sulphureus (Fres.) Thom and Church	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–
Penicillium humicola Oud.	–	–	3	5	4	5	5	4	4	4	4	2	3	3	4	5	5	3	5	5
P. notatum Westling	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–
P. funiculosum Thom	–	–	–	–	–	–	–	–	–	–	3	1	–	1	–	–	–	–	–	–

P. purpurogenum Stoll	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–
Paecilomyces fusisporus Saks.	–	–	–	–	–	–	–	1	–	1	1	–	–	1	–	–	–	–	–	–
Cephalosporium acremonium Corda	–	–	–	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–
Gliocladium roseum (Link) Thom	–	–	–	–	–	–	–	–	–	–	–	–	5	–	–	–	–	–	1	–
Alternaria tenuis Nees.	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–
A. humicola Oud.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	1
Humicola fusco-atra Traaen	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Scolecobasidium constrictum Abbott	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Helminthosporium anomalum Gilman and Abbott	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–
Hormiscium sp.	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
Fusarium nivale (Fries) Cesati	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	4	4	–
F. tricinctum (Cda.) emend.	5	–	2	5	1	5	–	5	5	3	5	5	5	5	5	5	4	–	5	4
Sclerotium sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3

TABLE VIII

Frequency of Fungal species in Cicer arietinum *plots (experimental)*

(10th November, 1964 to 25th March, 1965)

Fungi/plots	Nov. 10		Nov. 24		Dec. 10		Dec. 25		Jan. 10		Jan. 25		Feb. 10		Feb. 25		Mar. 10		Mar. 25	
	III	IV	III	IV	III	IV	III	IV	III	IV	III	IV	III	IV	III	IV	III	IV	III	IV
Mucor luteus Linn.	–	–	–	–	–	–	1	1	1	–	–	1	1	–	1	–	–	–	–	–
M. hiemalis Wehmer	1	4	2	3	3	1	–	–	2	–	–	–	1	1	–	–	1	–	–	1
M. plumbeus Bonorden	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rhizopus nigricans Ehrenberg	–	–	–	–	1	1	1	1	1	–	1	1	1	2	1	2	2	2	2	2
Phycomycetous sterile colony	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–
Zygorhynchus heterogamus (Vuill)	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–
Choanephora cucurbitarum (Berkley and Ravnel) Thaxter	–	1	–	1	–	–	1	–	1	1	–	–	–	–	–	–	1	–	–	1
Syncephalastrum racemosum (Cohn) Schroeter	–	2	–	–	2	3	1	–	–	1	–	–	–	–	–	–	–	–	–	1
Thielavia terricola (Gilman and Abbott) Emmons	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chaetomium globosum Kunze	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Aspergillus nidulans (Eidam) Wint	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
A. terreus Thom	3	–	3	–	1	2	3	1	1	1	2	–	1	–	1	–	2	–	3	–
A. flavus Link	–	5	5	3	5	3	2	4	1	5	–	1	5	2	5	2	–	2	4	3
A. candidus Link	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–
A. sydowi (Bain. and Sar.) Thom and Church	–	–	–	–	–	–	1	–	1	–	1	–	–	–	–	1	–	–	1	–

Penicillium humicola Oud.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
P. notatum Westling	3	2	1	2	5	3	5	5	5	5	5	5	1	5	1	5	5	5	3	5
P. funiculosum Thom.	1	–	1	1	2	2	–	–	1	–	–	–	1	–	1	1	–	1	1	–
P. purpurogenum Stoll	–	–	3	–	–	–	–	–	–	–	–	2	2	1	–	–	–	–	–	–
Paecilomyces fusisporus Saks.	1	–	–	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Sporotrichum chlorinum Link	–	1	–	1	2	–	2	–	1	–	–	–	1	–	2	–	2	–	–	–
Cephalosporium coremioides Raillo	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Gliocladium roseum (Link) Thom	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	3
Alternaria humiccla Oud.	–	–	–	–	–	1	1	1	–	–	–	–	1	–	–	–	–	–	2	3
Papulospora sp.	–	–	–	–	–	1	–	1	–	–	–	2	1	–	–	–	–	–	–	–
Humicola fusco-atra Traaen	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Scolecobasidium terreum Abbott	–	1	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–
Helminthosporium nodulosum (Berkley and Curtis) Sacc.	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
H. anomalum Gilman and Abbott	–	–	–	–	–	–	–	–	–	–	–	–	–	2	1	–	–	–	–	–
Fusarium nivale (Fries) Cesati	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–
F. oxysporum Schlechtendahl	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
F. tricinctum (Cda.) emend.	5	5	5	5	5	5	5	5	5	5	5	1	5	5	5	2	5	4	–	5
Myrothecium verrucaria (Albertini and Schweinitz) Ditmar	–	–	1	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Pestalotia monorhinca Speg	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–

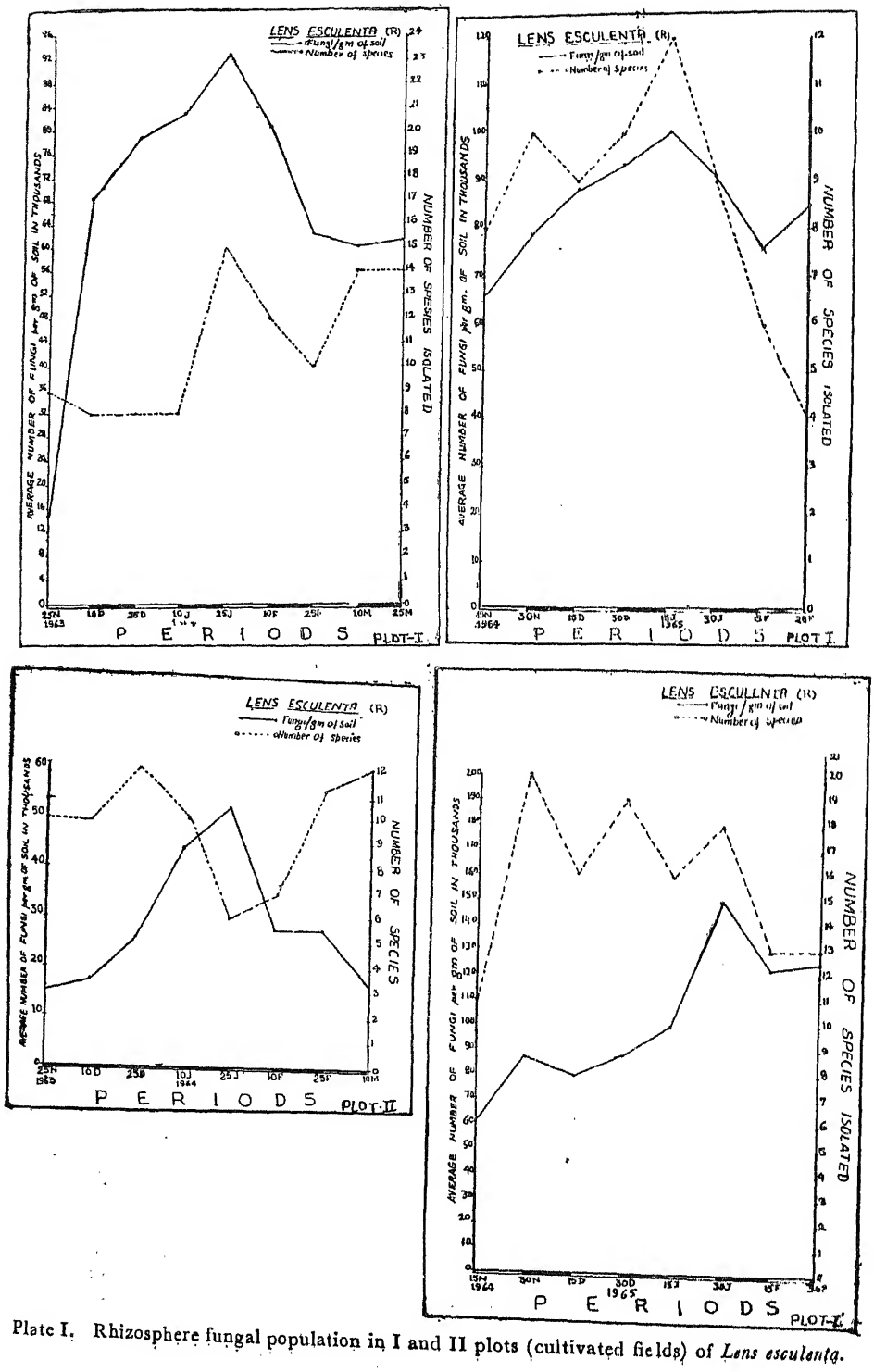


Plate I. Rhizosphere fungal population in I and II plots (cultivated fields) of *Lens esculenta*.

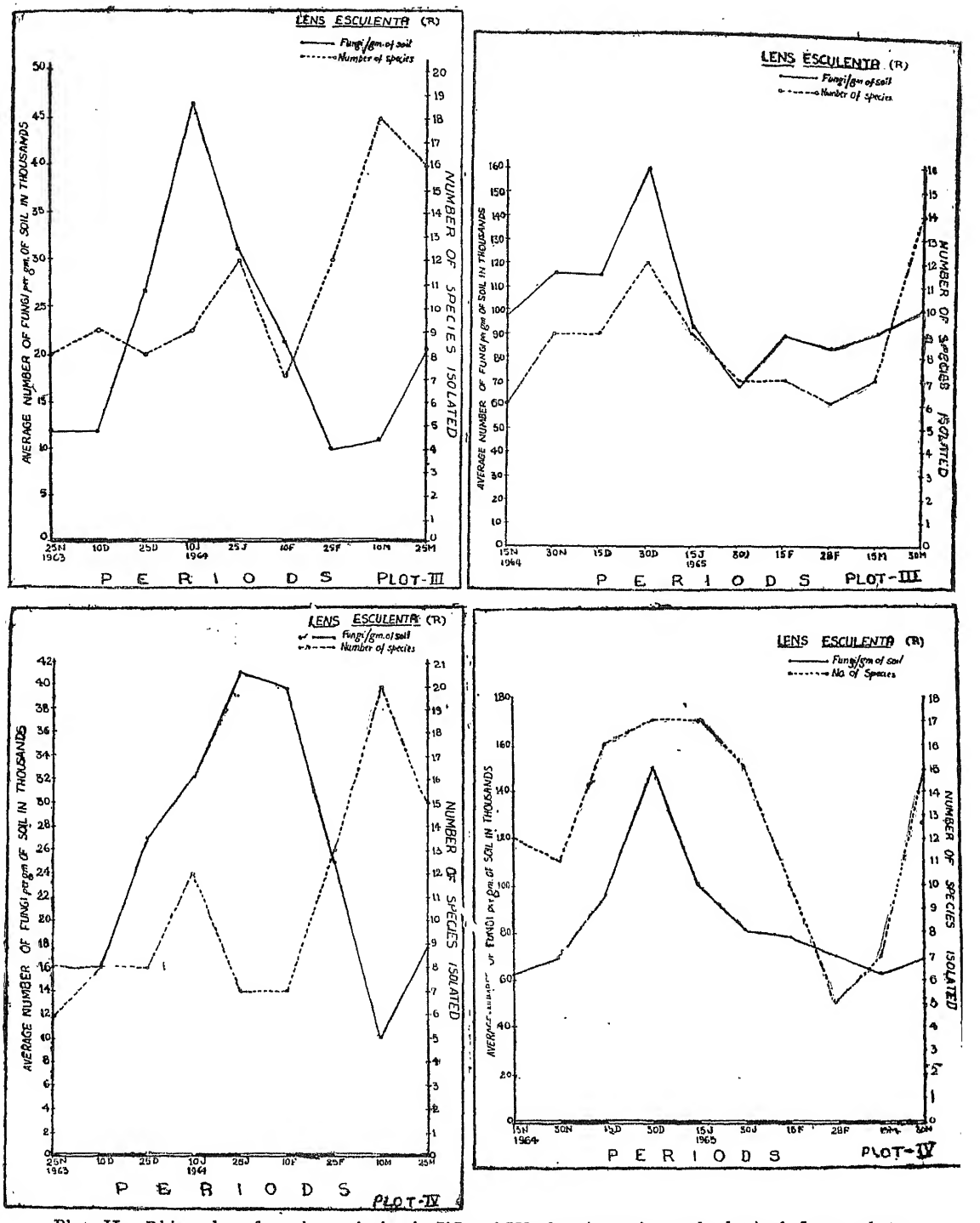


Plate II. Rhizosphere fungal population in III and IV plots (experimental plots) of *Lens esculenta*.

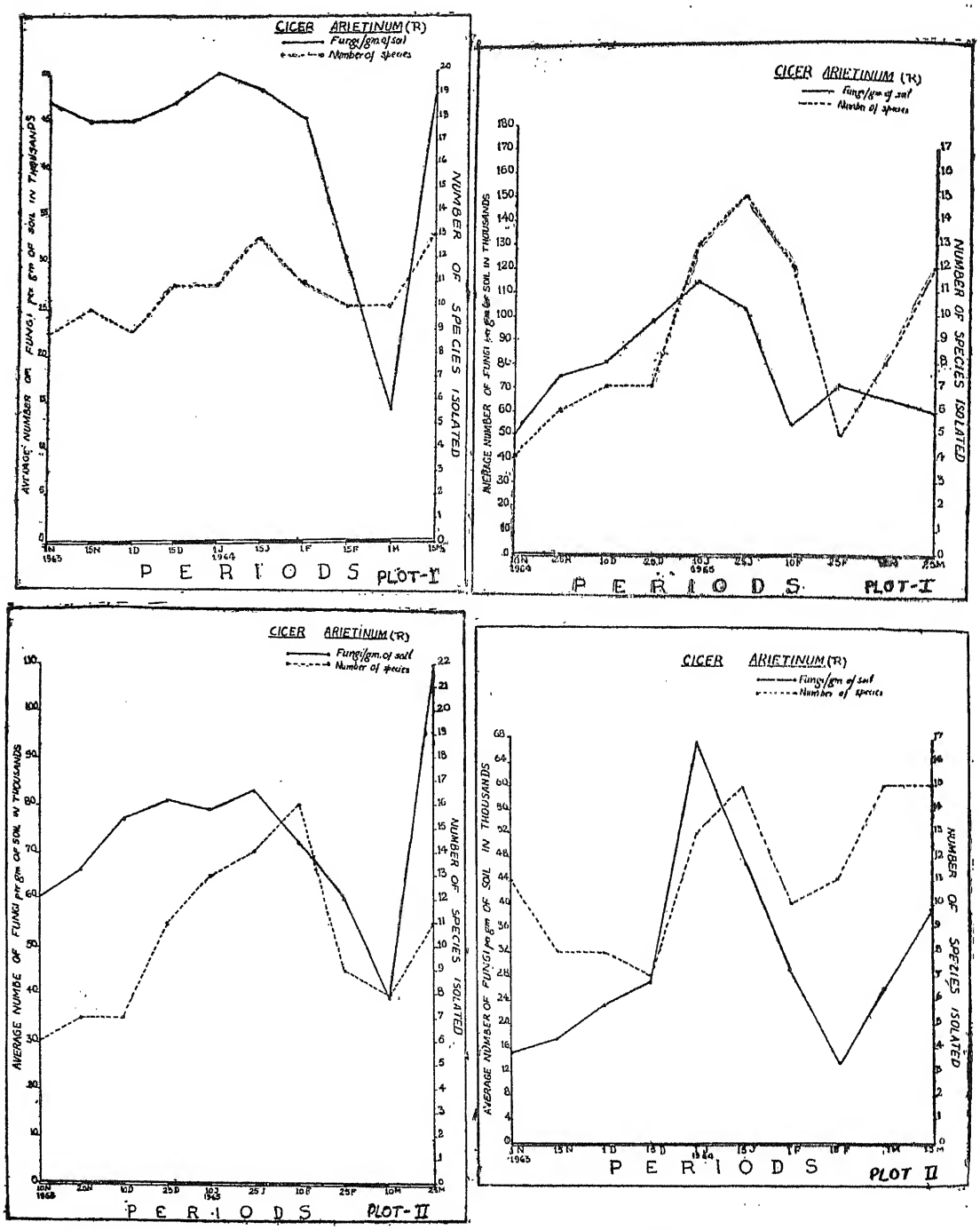
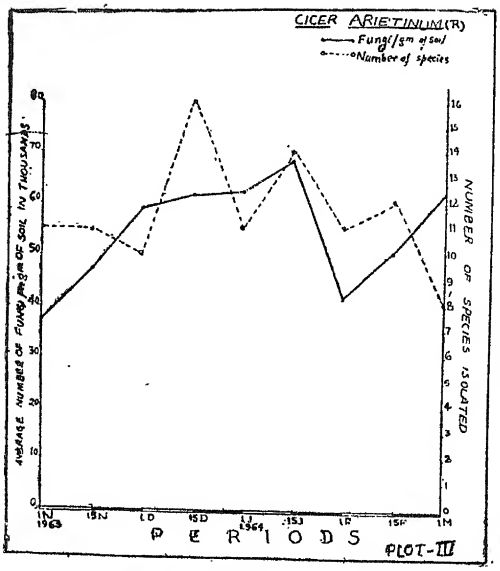
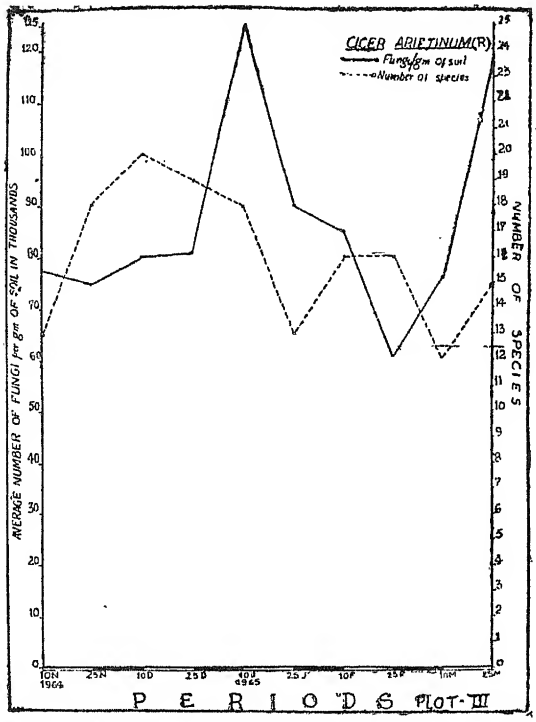
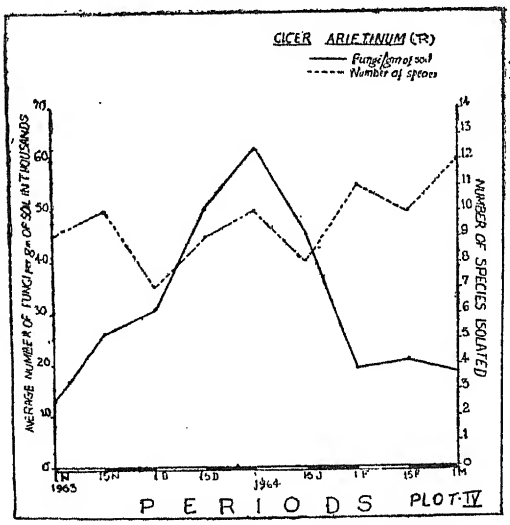


Plate III. Rhizosphere fungal population in I and II plots (cultivated fields) of *Cicer arietinum*.







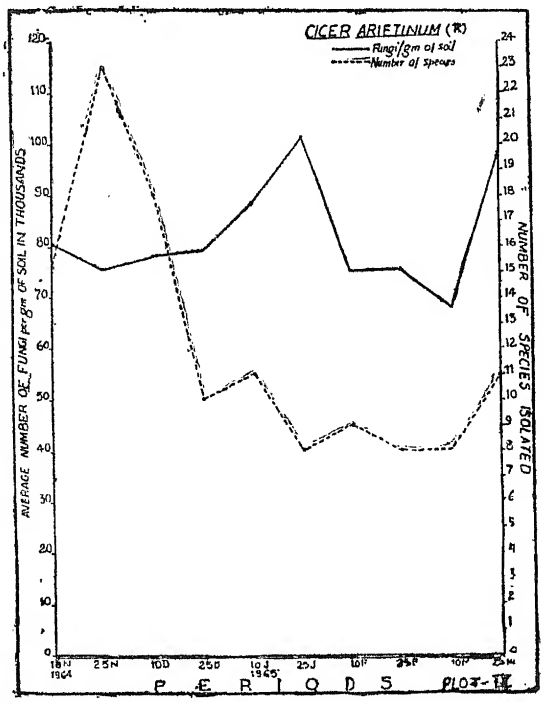


Plate IV. Rhizosphere fungal population in III and IV plots (experimental plots) of *Cireer arietinum.*

Summary

An investigation into the rhizosphere fungal flora of two cultivated legumes, viz. *Lens esculenta* and *Cicer arietinum* from seedling to senescent stages was undertaken. The fungal population continuously increased from the seedling stage and attained the higher peak at the time of flowering and fruiting of the cover plants. Later on the fungal flora decreased continuously, but with a rise at the senescent stage when the roots harboured dematiaceous forms as dominants.

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Apical Structure of the Root in Mimosaceae*

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Introduction

Pioneering investigations of workers like Janczewski (1874), Treub (1876), Kroll (1912), Schuepp (1926) and others form the source of our information of the root apical structure. Recently Guttenberg (1940, 1941), Allen (1947), Clowes (1950) and others have made valuable contributions to our knowledge of root apices. Zonation in root apices of various Leguminosae has received a good deal of attention. Eriksson (1878) placed the following members of the Leguminosae in his third type of dicotyledonous root apices—*Vicia sativa, Pisum sativum, Cicer arietinum, Phaseolus multiflorus, Lathyrus odoratus* and a few others. Flahault (1878) found after an extensive study that in genera *Lupinus, Cercis, Gymnocladus, Acacia, Mimosa* and *Guilandinia* there are distinct stelar initials and a common group of initials from which develop cortex, epidermis and root cap. Neumann (1939) and Guttenberg (1947) found in *Mimosa* and *Lupinus* that the promeristem consists of the plerome, periblem, protoderm and columella initials. A central cell gives rise to periblem and plerome. In *Arachis* roots (Yarbrough, 1949), *Pisum* embryo (Reeve, 1948), old primary roots of *Pisum* (Popham, 1955); *Phaseolus* embryo (Sterling, 1955) and old roots of *Glycine max* (Sun, 1957) there exists a similar organization as described by Janczewski in his IV type.

Material and Methods

Six locally occurring species of the Mimosaceae were selected for the present investigation. Seeds collected in one season were sown in July-August of the next season. The seedlings were allowed to grow for a week or ten days. In certain cases, for an easy germination, the hard seed coat was artificially loosened. Root tips were fixed on the spot in Randolph's modified Navashin solution and preserved in 70% alcohol. The materials were dehydrated and cleared by the ethyl alcohol-xylol series and blocked in paraffin wax. Root tips were cut in transverse as well as in longitudinal planes at 8–10 μ thickness. Sections were stained in Haidenhains iron-haematoxylin. Safranin-fast green combination was also tried but haematoxylin gave better results. The following plants were investigated :

1. *Prosopis juliflora* DC.
2. *Prosopis spicigera* Linn.
3. *Acacia arabica* Willd.
4. *Acacia farnesiana* Willd.
5. *Acacia senegal* Willd.
6. *Albizzia lebbeck* Benth.

*This work was carried out in Botanical Laboratories of Birla College, Pilani (Rajasthan).

Observations

1. The species of *Prosopis* are almost similar as regards the organization of different tissues in the root apex as well as vacuolation in the various zones.

2. *Acacia arabica* and *A. farnesiana* present a common type of tissue differentiation with minor differences.

3. *Acacia senegal* and *Albizzia lebbeck* possess similar types of root apical organization.

I. *Prosopis juliflora* and *P. spicigera*

The root apex is distinguishable into periblem, plerome and root-cap (Fig. 1 and 2). These regions converge upon a common centre which may be called a pole. The root-cap consists of two regions ; a peripheral zone and the central columella. Peripheral part of the root cap and columella arise independently from each other. Files of cells in the peripheral zone converge upon the columella. The number of rows around the columella gradually decreases towards the apex. The cells of the inner peripheral zone divide more actively by periclinal divisions than outer one. The inner peripheral part of the root-cap has initials situated around the cylindrical columella ; being most active near the pole (Fig. 2) as in *Fagus sylvatica* (Clowes, 1950). Neumann (1939) and Guttenberg (1940) have reported that the columella initials lie at the periphery of the columella cylinder along the axis. There are five cells at the pole seen in longitudinal section which divide, mainly transversely and thus contribute to the columella (Figs. 1 and 2). The cell rows retain their width, a long way from the pole but decrease towards the tip of the root ; ultimately merging with the peripheral part of the root cap.

Dermatogen : The outermost layer of the periblem encloses the root body peripherally ; there is no true dermatogen. Thus, the so-called epidermis is not laid down as a separate histogen in the root. It is simply a part of the cortical complex of cells unlike epidermis-root cap complex as in *Fagus* (Clowes, 1950).

Periblem : Starting from the plerome pole, initials for the periblem are located in the peripheral layer of the columella along its whole length. These cells stain densely and have large nuclei.

Plerome : "The plerome initials usually appear pentagonal or hexagonal in both transverse and median sections" (Clowes, 1950). This is true for both the species of *Prosopis*. They lie at the pole above the columella initials and are limited in number ranging from 3 to 6. Transverse divisions in the central region of plerome are infrequent and it is due to this reason that the cells here become longer than those at the periphery (Fig. 2).

Vacuolation : Vacuolation as seen in the various regions of the root-apex is as follows :

1. *Plerome* : It is the central solid core, the lower limit of which extends up to the upper end of columella. Its basal cells stain lightly and are nonvacuolate. Above this level the cytoplasm is dense in the central cells. The peripheral layers remain nonvacuolated for a long distance from the pole. They stain densely except near the pole. The cells destined to develop into xylem are the first to be vacuolated, followed by pith, phloem and pericycle.

2. *Periblem* : It is a portion which can be well distinguished outside the plerome, converging near the pole of the plerome. The cells of the periblem remain nonvacuolated for a long distance behind the pole. The cell layers adjacent to the plerome are the first to vacuolate and it spreads gradually centrifugally.

EXPLANATION OF FIGURES

[Ca—Columella ; pe—periblem ; pl—plerome]

Median longitudinal sections of root apex of :

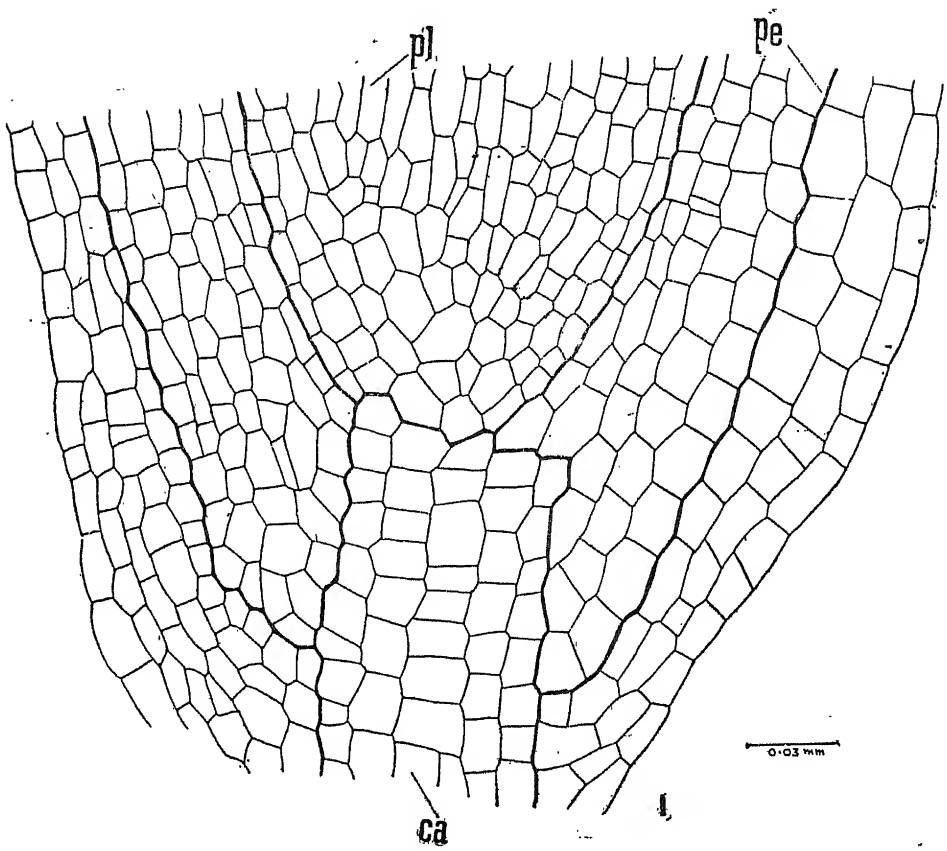

Fig. 1. *Prosopis juliflora*

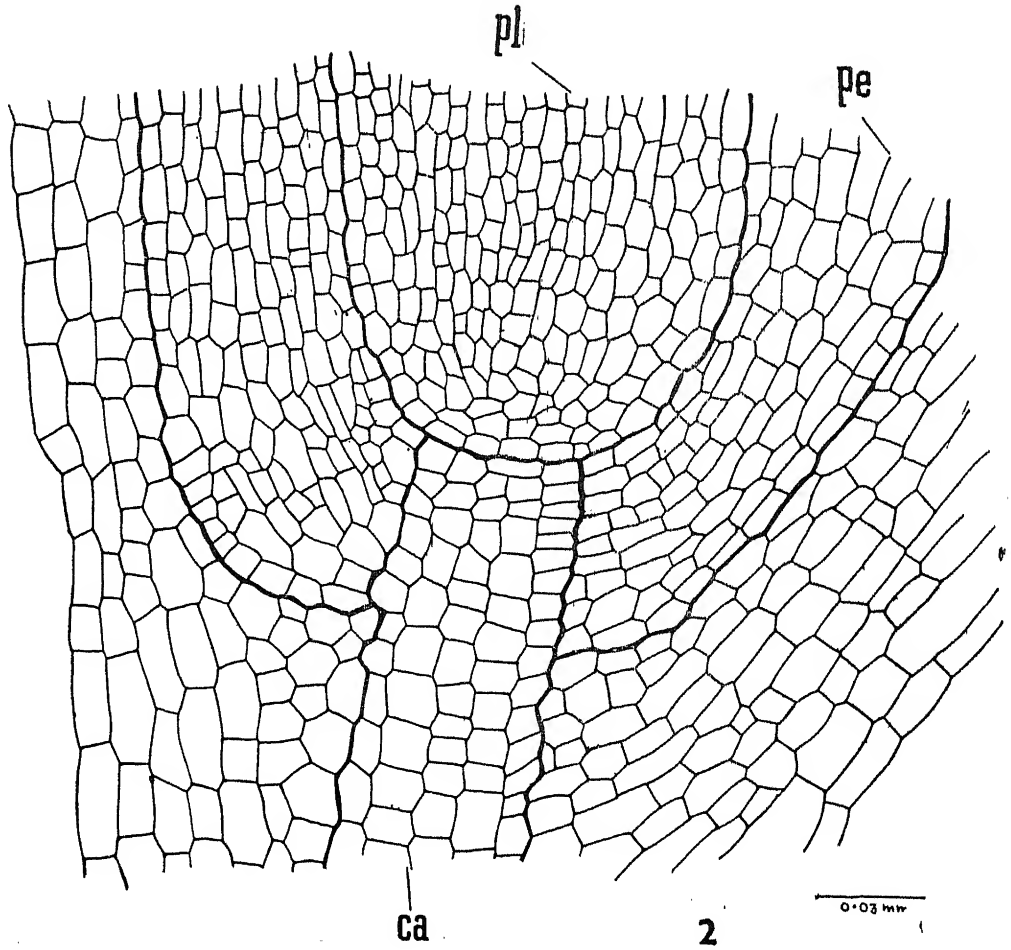

Fig. 2. *Prosopis spicigera*

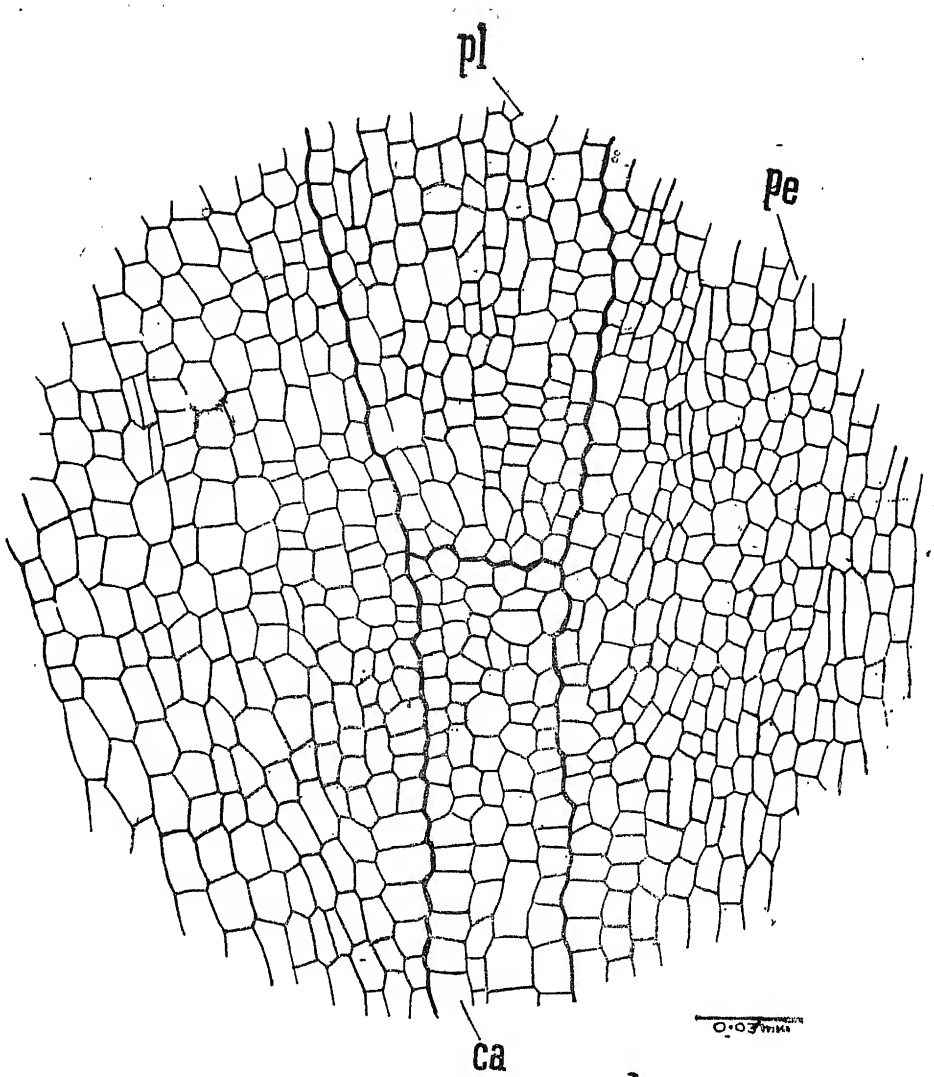

Fig. 3. *Acacia arabica*

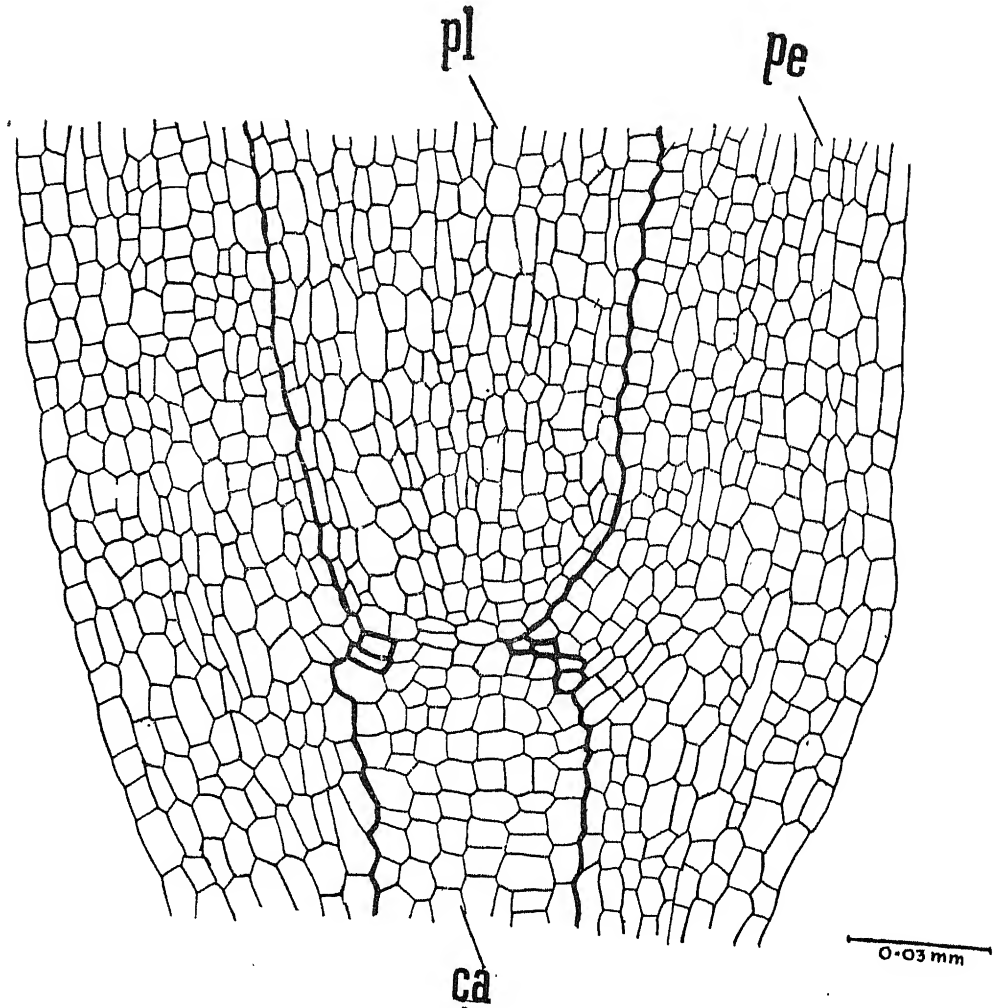

Fig. 4. *Acacia farnesiana*

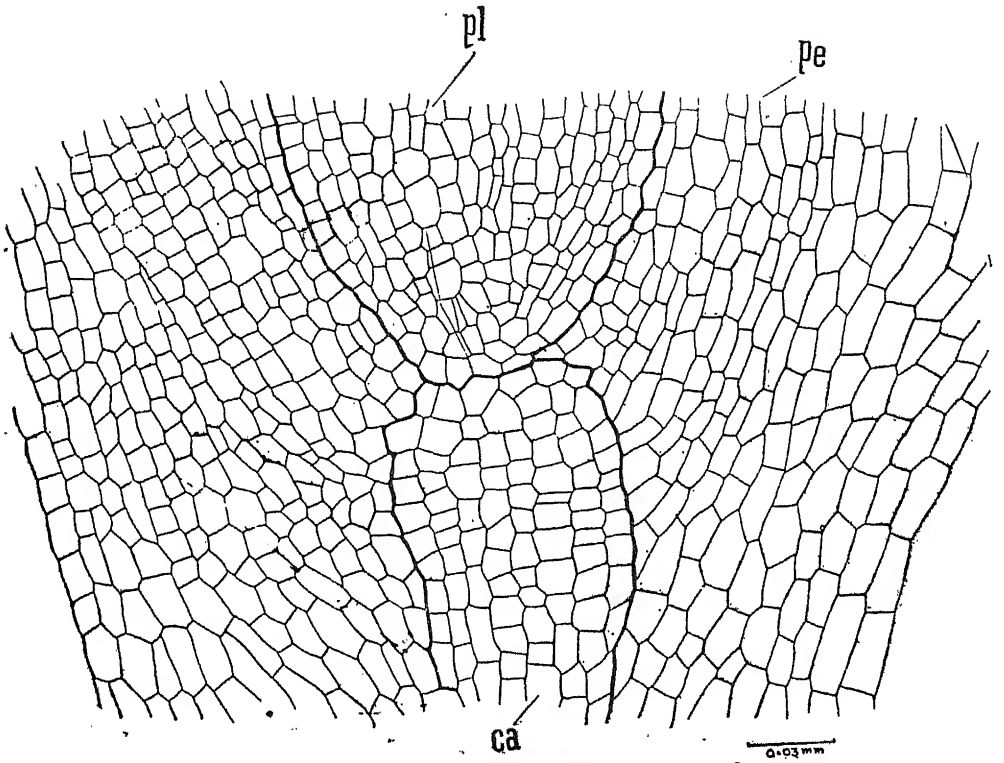

Fig. 5. *Acacia senegal*

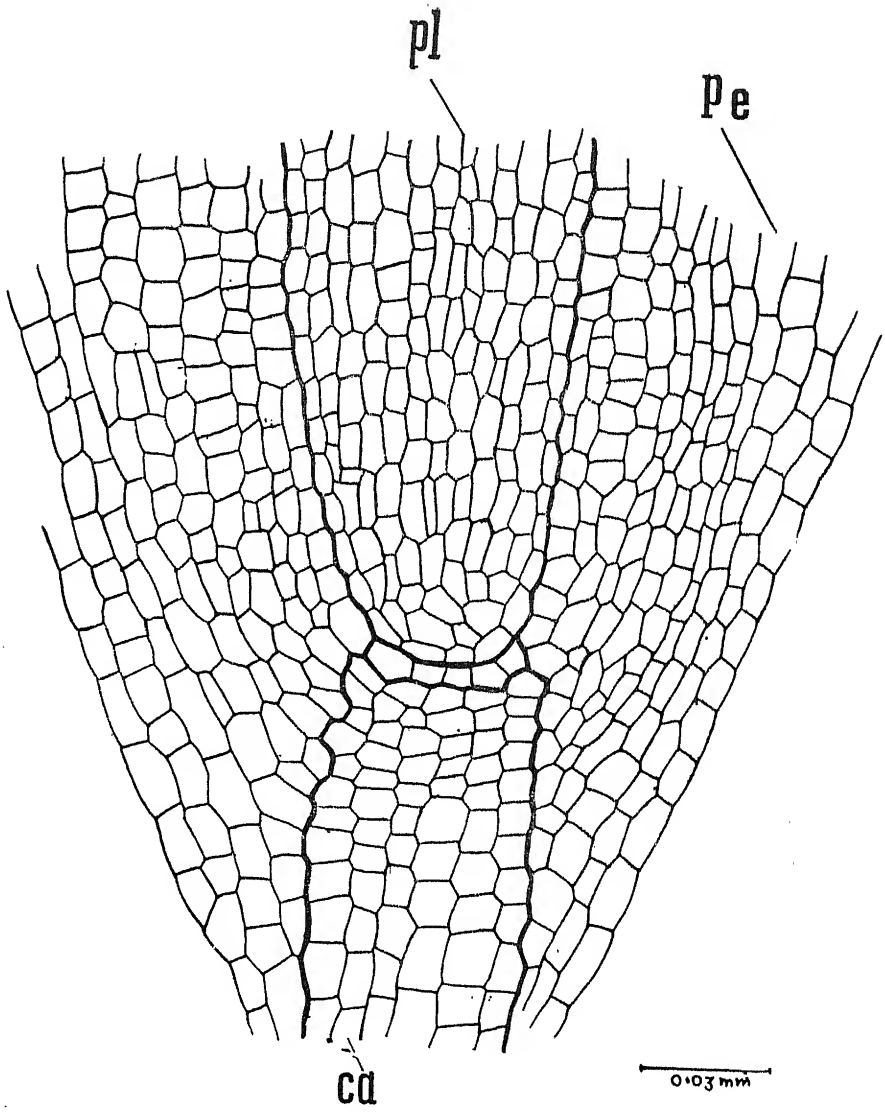

Fig. 6. *Albizzia lebbeck*

3. *Root-cap* : Peripheral part of the root-cap extends far behind. In general, the cells are poor in cytoplasmic contents, but those near the columella and adjacent the periblem have denser cytoplasm. Some of the cells situated away from the columella also have feeble protoplasmic contents. Almost all the cells of this part of root-apex are vacuolated to some extent

The cells of the columella near the plerome pole are densely cytoplasmic and nonvacuolated, but next three or four cell-layers towards the apex become vacuolated rapidly. All the cells are vacuolated towards the end of the root-cap.

Cell-division in the different histogens and their derivatives : The cells in the peripheral part of the root-cap which cover the root to a long distance divide both anticlinally and periclinally. The covering layer or the so-called dermatogen after getting segregated from the periblem shows T-divisions. The cell of the dermatogen divides periclinally, the outer daughter cell first elongates considerably and then shows only anticlinal divisions. The cells thus formed become the cells of the cap.

The inner cell, however, does not elongate or vacuolate and contains dense cytoplasm. It divides repeatedly longitudinally and every time the outer daughter cell metamorphoses into the cap-cell while the inner cell retains the capacity to divide and add to the cap. Such T-shaped divisions are called 'Kappe' where the head of 'T' is directed towards the root apex. On the other hand if it is directed towards the body of the root, as to increase the cell layers in that part, the divisions are called 'Korper' type. The outer portion of the peripheral part of the root cap is thus a product of repeated 'Kappe' type of division.

The columella cells divide only transversely as is evident from the constant number of rows constituting it. These divisions cease at the tip of the root apex.

Periblem cells near the pole divide mainly anticlinally, while away from it, periclinal divisions predominate. Sometimes typical Korper type of divisions occur in the central region of the periblem, nearer the pole of the plerome. Periclinal divisions, however, are more common in the inner part of the periblem to keep pace with increase in length of the plerome. Peripheral layers of periblem divide mainly by anticlinical divisions ; this keeps pace with increase in girth. The middle periblem layers vacuolate first and lose the capacity to divide further. They become elongated earlier than any other cells of the periblem, and form the layer cells in the mature root. The innermost layer of the periblem ultimately become the endodermis. There is no hypodermis even in the mature root. The peripheral cells of the plerome divide in various planes. In the central plerome a few periclinal divisions occur very close to the pole, followed by anticlinal ones. Thus, a constant number of central plerome rows is maintained.

Promeristem : The promeristem consists of initials of all the histogens whose boundaries cannot be delimited. It can be compared with an inverted cup as shown by Clowes (1950) in *Fagus* tap root. Columella and plerome initials are at the base of the cup while its sides are formed by the initials of the periblem and inner peripheral part of the root-cap. There are common initials for the plerome and columella, forming a sort of plate. This is confluent at the sides of the cap with the initials of periblem and peripheral part of the root-cap. For dermatogen there are no separate initials but the outermost layer of the periblem gets differentiated into an epidermis, just behind the growing root apex.

Periblem initials are the connecting link between the columella and plerome initials on one hand and the initials for the peripheral part of the root cap on the other. It appears that the plate of initials common to the plerome and columella,

divide transversely. Upper daughter cells, by further divisions form the plerome, while the lower one contribute to the columella.

II. *Acacia arabica* and *A. farnesiana.*

In both the species the basic pattern of zonation in the root apex is similar, with certain minor differences. As in *Prosopis* the root-cap is extensive. Vacuolation and pattern of cell division in the various parts is similar to that described for *Prosopis.*

1. *Root-cap* : This region is clearly demarcated from the columella due to a difference in orientation of its cells. The cell layers are obliquely oriented at the level of the plerome pole and are curved on the flanks of the columella. In *A. arabica* some of the rows, especially the outer ones, follow more or less a parallel course for some distance with columella, then curving towards it. Kappe type of divisions have not been observed. The columella is broad in *A. farnesiana* (Fig. 4) and narrow in *A. arabica* (Fig. 3). Moreover, it is more elongated in the latter than the former. In any case there is, however, no relation between the columella and the peripheral part of the root cap. They do not contribute to each other.

Periblem : Initials for this zone can be made out in *A. farnesiana* (Fig. 4) while in *A. arabica* (Fig. 3) they are not distinct. In both the outer periblem constitute the peripheral part of the root-cap. Thus, there is present the periblem-root cap complex, called "calyptro-periblem" by Allen (1947). This complex is concerned on one hand with the formation of the peripheral part of the root cap and on the other builds up the periblem layers. Inner periblem initials are located on the periphery of the columella a short distance from pole towards the apex in *A. farnesiana* Fig. 4). However, in *A. arabica* the initials for this zone are not distinct (Fig. 3). It may be assumed, therefore, that the periblem in this case is embryonic in nature and no new layers are added to the mature root apex. Korper type of division does not occur in the periblem. Tannin is present in the periblem as well as in the root-cap.

Dermatogen : Like *Prosopis,* a true dermatogen is not established. It is the outermost layer of the periblem behind the root apex that covers the root. This layer differs from that of *Prosopis* in that, it does not show any Kappe type of division, and does not add to the bulk of the peripheral part of the root-cap.

Plerome : This central solid region of the apex is broad in *A. farnesiana* (Fig. 4) and narrow in *A. arabica* (Fig. 3). It is devoid of tannin deposits.

Promeristem : It differs in the two species. The promeristem consists of the common initials for columella and plerome. They are situated at the base of the plerome pole and at the head of the columella. Distinct initials for periblem are not seen. This type of promeristem is found in *A. arabica* and it is comparable in this respect with that of *Arachis hypogea* (Yarbrough, 1949) and *Pisum sativum* (Popham, 1955). In *A. farnesiana,* in addition to these common initials, are the periblem initials, around the columella, nearer the plerome pole. The promeristem in this species therefore, is in the form of an inverted cup ; its base being made of the common initial and sides of the periblem initials.

III. *Acacia senegal* and *Albizzia lebbeck.*

Root-cap in both the species consists of peripheral part of the root cap and columella (Figs. 5 and 6). The peripheral part is formed from the calyptro-periblem complex as described for *Acacia* species. Vacuolation is characteristic of this tissue but in this case its cells are not much vacuolated. Elongated columella is 4

to 6 cells across and its cells are rectangular in appearance. They are well demarcated from the peripheral cells of the root-cap. Even at the extremity of the root, its cells remain distinct and separable from the peripheral root cap cells. Initials for the columella are located at its head, just below the initials for plerome. The peripheral initials, however, appear to give rise to both the columella and periblem.

Periblem : Inner periblem layers converge towards the base of the plerome pole. In these rows the initials are peri-columnar. Korper type of divisions are frequently met with in these layers. Outer periblem layers form the peripheral part of the root-cap.

Plerome : Unlike other species of Mimosaceae described herein (Figs. 1, 2, 3 and 4), possess a distinct zone of the plerome initials at its base. These form a plate and divide to add cells towards the plerome region only (Figs. 5 and 6). They do not contribute to any other zone.

Dermatogen : The outermost layer of the periblem near the plerome pole differentiates as a 'dermatogen' layer. Once organized, its cells divide anticlinally only.

Promeristem : The promeristem consists of initials for plerome at its base ; peripherally situated common initials for columella and the periblem, and the initials for the columella in the centre, just below the plerome initials. Though dermatogen is organized, it is a part of the periblem. Root-cap is formed from the calyptro-periblem complex.

Discussion

The species of the family Leguminosae show diverse pattern of apical organization of the roots, Janczewski (1874), Treub (1876), Flahault (1878), Kroll (1912) and others modified Hanstein's (1868) histogen theory for their own interpretations of the apical structure of the root. All the species investigated here have common initials in the root apex for all the tissues, namely the root-cap, cortex, stele and epidermis. Haberlandt's (1914) type 4, embraces these root apices since the entire cortical meristem gives rise to cap while protoderm remains undivided.

All these species show the formation of peripheral part of the root cap by the periblem layers. Thus, "calyptro-periblem" is present (Buchholz and Old, 1933). In *Prosopis juliflora* and *P. spicigera*, additional initials for the root-cap are located below the pericolumnar periblem as reported in *Fagus sylvatica* (Clowes, 1950). The species exhibiting a common meristem except *Acacia senegal* and *Albizzia lebbeck*, show a total absence of dermatogen in their root apices. Absence of an epidermis is said to be the characteristics feature of gymnosperm roots. Yarbrough (1949) has shown this structural similarity in *Arachis hypogea* in common with gymnosperms. This is also true for *Prosopis juliflora, P. spicigera, Acacia arabica* and *A. farnesiana*.

Guttenberg (1960) believes that the root apices in dicotyledons are not of the gymnosperm type. According to him the error of the earlier authors is due to the fact that they considered only the mature roots, and not the developmental stages. He finds that the histogens develop from a central region which is either occupied by a single cell or by a plate of few cells known as 'joining cells'. In the Leguminosae columella and plerome are joined together (Tiegs, 1912). This corresponds to the "transversal meristem" of the earlier authors. However, Guttenberg (1960) does not call it by this name since he believes that it is not transverse but like a swollen shell formation. He does not classify the root apex in the Leguminosae into various types. In the plants of the present study the root

promeristem is in the form of an "inverted cup" as described in *Fagus* (Clowes, 1950).

Root cap and its origin : This study of root apex reveals that the root cap may be formed in different ways. Presence of independent initials is a common feature in monocotyledons. In dicotyledons, however, the root cap is organized either from dermatogen or the periblem. According to Hanstein (1868) and Haberlandt (1914) there does not exist a separate histogen for the root-cap. It is a product of the dermatogen (Hanstein, 1868) or Protoderm (Haberlandt, 1914). Nageli and Leitgeb (1868) stated that the root-cap arises in the endodermis in *Oryza sativa*. This has been confirmed by Janczewski (1874) and Van Tiegham and Douliot (1888).

On the mode of cap formation, Holle (1876) assigned root apex to two categories : (1) root-cap from an apical cell ; and (2) root-cap from the periblem. Holle (1876), however, recognised some variation in certain Leguminosae, but he considered it merely a degeneration of the type, not wotthy of separate classification. Recently, Guttenberg (1960) divides "the growing roots" of dicotyledons into two types : (1) 'closed type' having a clear separation of the cap and periblem, thereby showing the presence of a dermocalyptrogen complex, and (2) 'open type' having a common generative centre for all the histogens ; root-cap is derived from the periblem. The present study reveals that the cortical layers of the root body give rise to the peripheral part of the root-cap. This is similar to the gymnosperms where the "root-cap" is interpreted as a "modified cortex" (Buchholz and Old, 1933 ; Guttenberg, 1940 ; Allen, 1947 and Spurr, 1949).

As regards the central part of the root-cap, it is clearly distinguishable into an elongated cylinder or columella, composed of vertical files of cells from the oblique cell-layers, flanking on its periphery. The cells of the columella divide mainly transversely while those of the peripheral part of the root-cap exhibit 'T' type of divisions, the head of the T being directed towards the flanks. Based on the cell complexes, Schuepp (1926) postulated "Korper-Kappe" hypothesis. Reinke (1872), Wagner (1939), Clowes (1950, 1954, 1959) and Sterling (1955) have also recognized this pattern of cell division in the root-cap. The earlier literature does not mention an independent origin of this structure, although its presence was recognized. It was assumed that the same initials give rise to the root-cap as well as the columella. However, later authors (Allen, 1947 ; Spurr, 1949 and Kasapligil, 1954) recognized origin of columella and peripheral part of the root cap separately. Relation of the "peripheral region" (Allen, 1947) with the columella was described by Spurr (1949) who stated that the columnar initials do not contribute to the peripheral region of the cap. However, Schopf (1943) described a contribution of the columella to the peripheral region. Peripheral cells of the columella shift their polarity rather abruptly and grow upward and radially to form the peripheral part of the cap. Wagner (1939, and Clowes (1954) recognized these two regions in the broad root-apices ; they do not mention a separate histogen for the columella.

It is difficult to apply Hanstein's concept to any species under investigation. Schuepp's Korper-Kappe hypothesis, finds its application in certain cases. A Korper pattern is exhibited by the periblem layers which constitute the root cap. Nagelian apical cell concept further revived by Neumann (1939) and Guttenberg (1940, 1947) as the "central cell" or "initial group" (Brumfield, 1943) hypothesis is not applicable to any case of the present investigation.

Summary

Six species of Mimosaceae are investigated for their root apex organization.

Prosopis juliflora and *P. spicigera* show similar organisation of tissues in the root apex. A calyptroperiblem complex is present but true dermatogen layer is lacking. The promeristem consists of initials for columella, plerome, periblem and peripheral part of the root-cap.

In *Acacia arabica* "a transversal promeristem" is observed while *Acacia farnesiana* presents it in the form of "an inverted cup". In both no separate dermatogen layer is laid down.

Calyptroperiblem complex is observed in *Acacia senegal* and *Albizzia lebbeck* also. A distinct layer of dermatogen covers the distal part of the root-body. It is the outermost layer of the periblem. Promeristem consists of the initials for plerome, columella and periblem.

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Studies on the anatomy and histology of the alimentary canal of a carp, *Tor putitora* (Ham.).

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Tor putitora (Ham.) is one of the major carps and provides a valuable food for the fish eating population. It occurs throughout the hilly districts of India and the development and protection of this fish constitutes a major problem.

Plenty of information is available on the anatomy and histology of the alimentary canal of fishes. Important contributions on the digestive tube are by Islam (1951), Al-Hussaini and Kohly (1953), Kapoor (1953, 1957 and 1958), Barrington (1957), Nagar and Khan (1958), Sarkar (1959), Burnstock (1959), Swarup (1959), Chandy and George (1960), Ishida and Sato (1960), Chaudhary and Khandelwal (1961), Khanna (1961), Mohsin (1962) and Vickers (1962).

Live fish were collected from various rivers and rivulets of Dehradun and dissected out carefully to study the gross anatomy. The disposal of mucosal fold was also examined. Selected portions of the digestive tube were fixed in Bouins fluid. Sections of 6 to 8 μ thickness were cut and stained with Delafields haemotoxylin and counterstained with Eosin.

Anatomy : The alimentary canal (Fig. 1) comprises of the buccal cavity, the pharynx, the oesophagus, the intestinal bulb and the intestine terminating at anus. Associated glands are liver and pancreas.

The short gaped mouth is crescent shaped, protractile and is bounded by a pair of lips. The lips show variations. In some lips are fleshy and continuous at the angles of the mouth. The lower lip is broad and produced into a median lobe. In others lips are fleshy and bear minute rounded papillae. The snout is blunt. In some the snout is slightly more pointed.

The mouth leads into a dorsoventrally compressed buccal cavity. A maxillary oral valve is present (Fig. 2) as it is found in *Catla catla* and *Barbus stigma* (Kapoor, 1957*b*) The palatal folds are mild and longitudinal, while those of the floor are smooth, mild and possess an elevated mucosal region representing an indistinct tongue.

The pharynx is a posterior continuation of the buccal cavity and is laterally perforated by the gill slits. Functionally the anterior pharynx is respiratory and the posterior one is for the mastication of the food material. The anterior pharynx is triangular, bearing papillated mucosa. The gill rakers of this region serve as sieve. The posterior pharynx is small and bears a horny pad under the basi-occipital, while on the floor are two sets of teeth which are borne on the inferior pharyngeal bones and are arranged in the order of 2, 3, 5/5, 3, 2. The pad teeth form the masticatory apparatus as observed by Kapoor (1957*b*). Each functional tooth has a conical tip and dentition is homodont and polyphyodont.

The pharynx passes into a short and thick-walled oesophagus which continues into an intestinal bulb through a narrow constriction. The intestinal bulb

is a sac like structure which lies in a median line, dorsally to the coils of intestine and ventrally to the air-bladder, and extends upto the posterior end in the abdominal cavity. The bile and pancreatic ducts open by two separate openings into the anterior region of the intestinal bulb. The intestine proper is elongated, relatively thin-walled and occupies a greater part of the coelom. The terminal parts of the intestine forms a rectum making its exit through anus which is situated infront of the urinogenital aperture.

The oesophagus possesses prominent longitudinal but low folds (Fig. 3*a*). Mucosal folds of the intestinal bulb are of honey-comb pattern in the anterior region (Fig. 3*b*), but the folds of zigzag nature (Fig. 3*c*) are observed in the posterior region of the intestinal bulb. The anterior region of the intestine has transverse folds (Fig. 3*d*) while the posterior part possesses longitudinal folds (Fig. 3*e*). Folds are longitudinal and oblique (Fig. 3*f*) in the terminal parts of the intestine.

The liver is a compact, brownish, bilobed gland on either side of the intestinal bulb. It is joined at three places by connectives. The gall bladder lies in between the two lobes of liver and serves as a store house for the bile juice brought through hepatic ducts. Pancreas is of diffused type spread over a greater part of the visceral cavity.

Histology : The histology of a barbel shows (Fig. 4*a*) that the epidermis is stratified having cuteneous tastebuds and small but sparsely distributed mucous cells. The central core of dermis lacks the axial rod and is occupied by vascular and nervous elements. The lip consists of mucosa and submucosa (Fig. 4*b*). The mucosa is made up of stratified epithelium ; the basal layer is distinctly columnar, while the rest of the cells are polygonal or oval. The mucous cells are few. Tastebuds are present in large numbers. The submucosa is comprised of connective tissue fibres, separated from mucosa by a basement membrane.

In the oesophagus (Fig. 4*c*) the mucosa consists of columnar epithelium. Mucous cells are present but the tastebuds are not distinct. Submucosa is comprised of collagenous connective tissue. The muscularis is made up of an inner longitudinal and an outer layer of muscles. Striated muscles are also observed and serosa is thin in this region.

The intestinal bulb consists of mucosa, submucosa, muscularis and serosa (Fig. 4*d*). The epithelial cells of mucosa are slender, columnar with a covering of top plate except at mucous cells. Each epithelial cell has an oval nucleus situated near the central or basal part of the cell. Mucous cells are scattered in between the epithelium and wandering cells are in abundance. The tunica propria fibres support the epithelial folds. The submucosa is made up of connective tissue fibres with blood capillaries. The muscularis consists of a thick inner circular layer of smooth muscles and a thin outer longitudinal layer. Connective tissue lies between them. Serosa is a single layer of flattened peritonial layer cells.

Intestine (Fig. 4*e*). Four coats of intestine are mucosa, sub-mucosa, muscularis and serosa similar to that of the intestinal bulb. The epithelial lining has three common types of columnar mucous and wandering cells. Tunica propria is of fibrous nature. The sub-mucosa has a connective tissue with numerous blood vessels. The muscularis consists of a large inner coat of circular smooth muscles and an outer layer of longitudinal muscles. The serosa is single layered with flat cells.

Rectal region (Fig. 4) shows usual layers and mucous cells are in abundance in the mucosal layer of this region.

Food and feeding habits: The fish normally feeds upon green filamentous algae (Spirogyra and Ulothrix), insect larvae, small molluscs, water plants and slimy deposits on the rocks. The intestine is about 2·6 times as long as the length of the body. According to the diversity of the food, *Tor putitora* is considered to be an omnivorous.

In most of the dissections, the intestinal bulb is found to be empty. This indicated that feeding is probably intermittent in this fish. The protrusible mouth along with horizontal slightly upwardly directed opening, allows the fish to secure a good grasp of the food material specially the algal filaments and other aquatic plants. The lips which are fleshy and well developed, help to secure mud and other materials from the bottom. The two pairs of barbels are primarily used for exploring the food especially small food particles combined with mud at the bottom and on the rocks.

Discussion

Cyprinoid fishes lacking teeth on the jaws have well-developed pharyngeal teeth on modified fifth branchial arches. The most comprehensive study of the pharyngeal teeth is that of Chu (1935). He refers the teeth of Cyprinoids to three principal categories – compressed, depressed and conical. In *Tor putitora* the teeth are conical. The teeth masticate the food in an efficient manner.

Tor putitora possesses the intestinal bulb. In Cyprinoid fishes namely *Barbus sarana, Chela bacaila, Amblypharyngodon mola, Esomus deuricus* and *Aspidoperia marar* (Khanna 1961) has reported similar condition. Earlier a similar feature was reported by Rogick (1931) in *Campostoma anomalum,* Curry (1931) in *Cyprinus carpio communis* and Girgis (1952) in *Labeo horrie*, Kapoor (1957 and 1958) in *Barbus stigma* and *Catla catla* respectively. The absence of gastric glands and the opening of bile duct in the anterior part of intestinal bulb are sufficient evidences that the stomach is absent. The intestine proper is however, large and coiled structure. The great increase in the bodily bulk relative to the length necessitates increase in the intestinal mucosal surface and this is brought about by an increase in the relative length of the gut. In *Tor putitora* the intestine proper is about 2·6 times the length of the body as described earlier.

The rectum in *Tor putitora* is distinguished from the rest of the gut by its straight course upto the anal aperture. It shows low longitudinal folds. Moreover the mucous cells are in abundance. A rectal region is described by Sarbahi (1939) in *Labeo rohita,* Al-Hussaini (1945) in *Scarus sordius,* Nagar and Khan (1958) in *Mastacembelus armatus* and Chitray and Saxena (1961) in *Heteropneustes fossilis* and *Clarius batrachus.*

The barbels of *Tor putitora* shows a similar structure as that of *Barbus sarana* (Sato and Kapoor, 1958) and *Labeo calbasu* (Nagar and Mathur, 1958).

The histology of the lips of *Tor putitora* is unlike that of *Catla catla,* but dissimilar from the observations of Mookerjee and Ganguli (1951) that there are no taste papillae in the lip.

The structure of the intestinal bulb is similar to *Barbus stigma* and *Catla catla,* (Kapoor 1957 and 1958) and to a certain extent with that of *Barbus sarana* (Mohsin, 1962).

In *Tor putitora* the rectal region shows the abundance of mucous cells. The concentration of mucous cells is maximum in the rectum. Al-Hussaini (1945 and 1949) characterises such abundance of goblet cells, a distinguishing feature of rectum. Girgis (1952) also observed the goblet cells in plenty in the last portion of the gut.

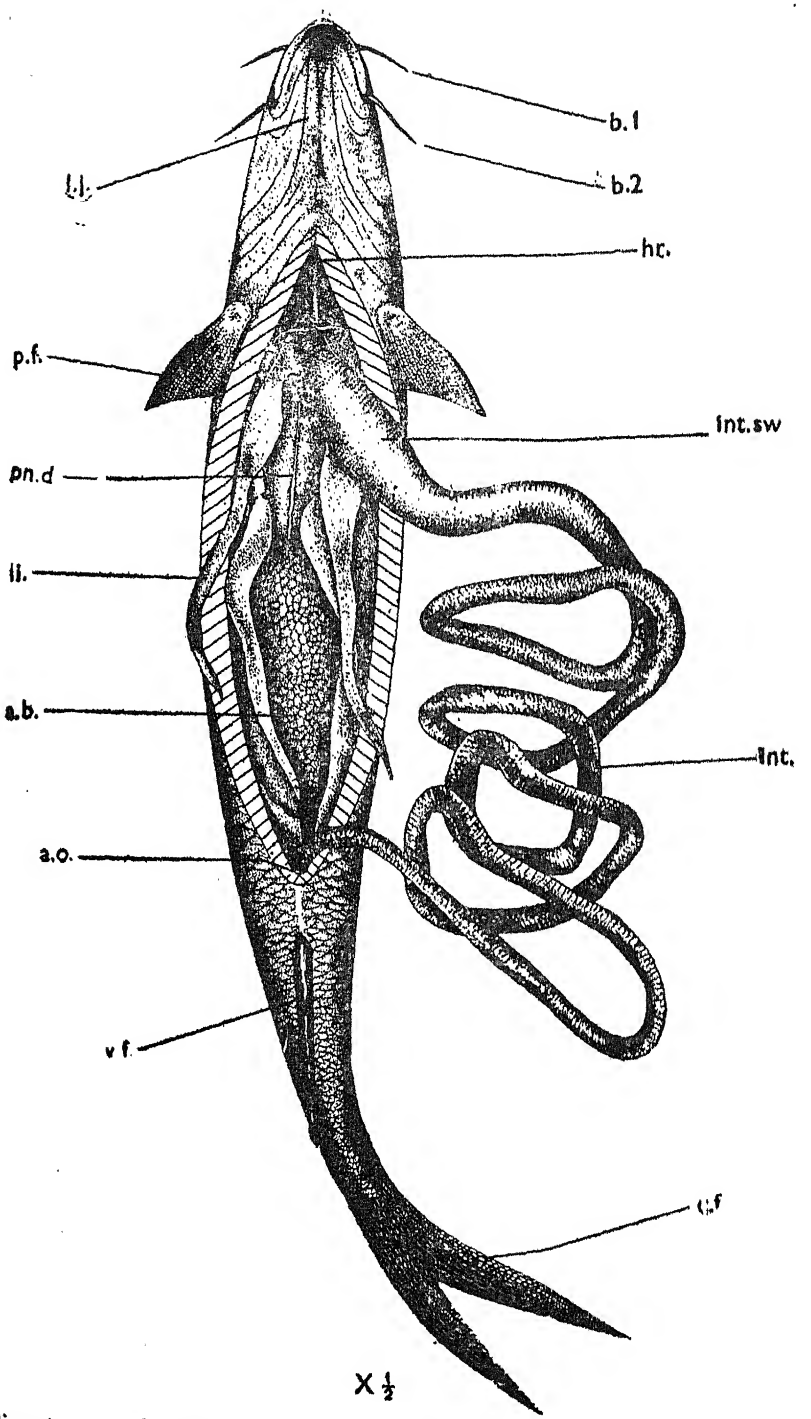


Fig. 1. Alimentary canal (slightly displaced), ventral view—a.b.—air bladder ; a.o.—anal opening ; b^1 and b^2—barbels ; c.f., caudal fin ; htr.—heart ; int.—intestine ; int. sw.—intestinal swelling ; li.—liver ; l.j.—lower jaw ; p.f.—pectoral fin ; pn.d.—pneumatic duct ; v.f.—ventral fin.

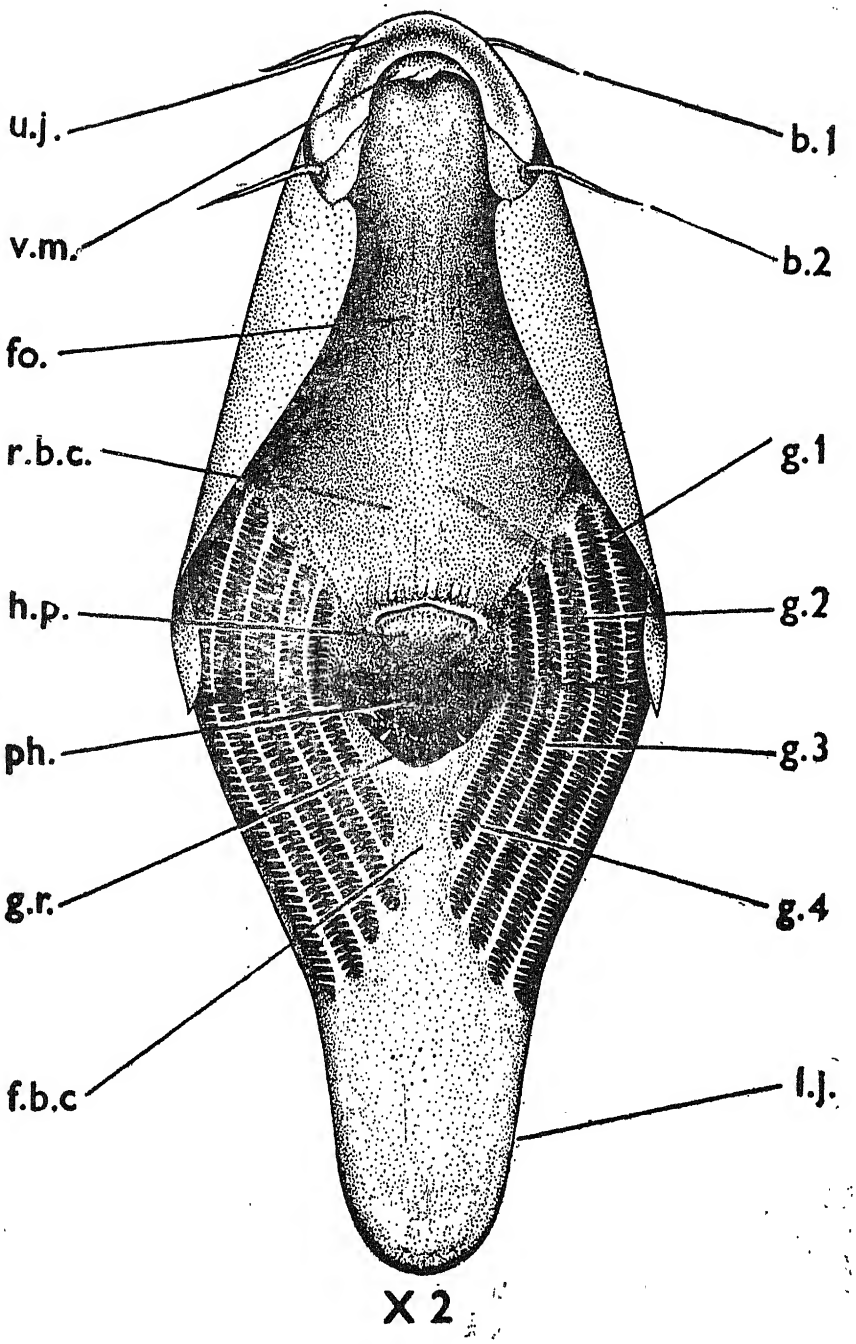
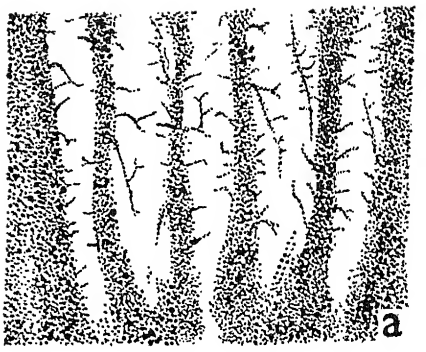
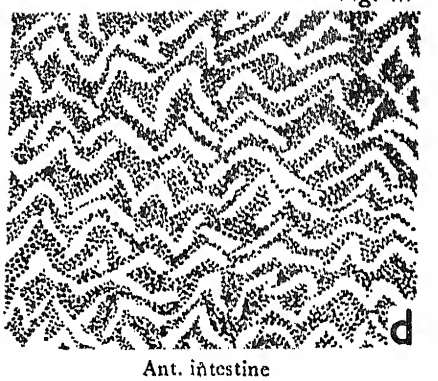


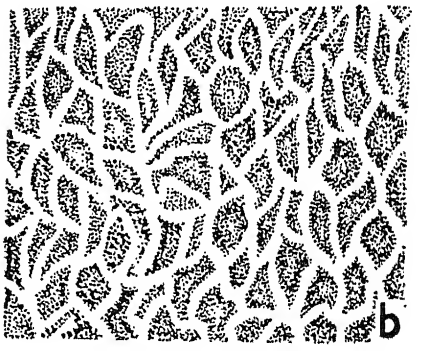
Fig. 2. Buccal cavity (jaws expanded), ventral view—b^1, b^2—barbels ; fo.—fold ; f.b.c.—floor of buccal cavity ; g^1 to g^4—gills ; g.r.—gill raker ; h.p.—horny pad ; l.j.—lower jaw ; ph.—pharynx ; r.b.c.—roof of the buccal cavity ; u.j.—upper jaw; v.m.—velar membrane.



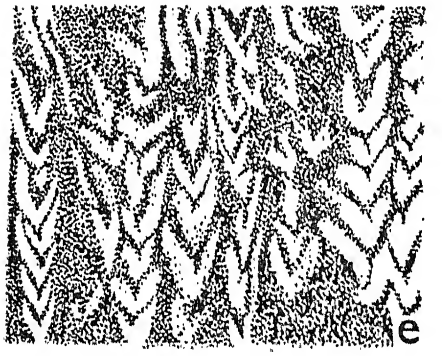
Oesophagus



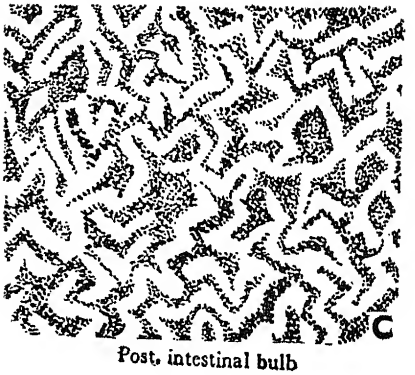
Ant. intestine



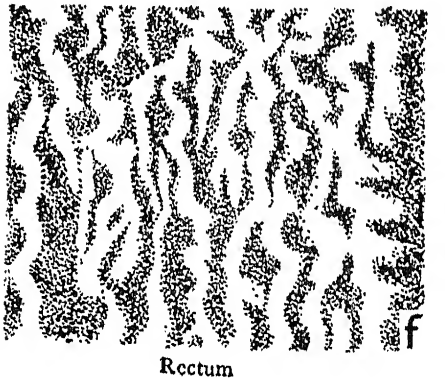
Ant. instestinal bulb



Post. intestine



Post. intestinal bulb



Rectum

Fig. 3*a*. Folds of the oesophageal region.
Fig. 3*b*. Folds of the anterior region of the intestinal bulb.
Fig. 3*c*. Folds of the posterior region of the intestinal bulb.
Fig. 3*d*. Folds of the anterior part of the intestine.
Fig. 3*e*. Folds of the posterior part of the intestine.
Fig. 3*f*. Folds of the rectum.

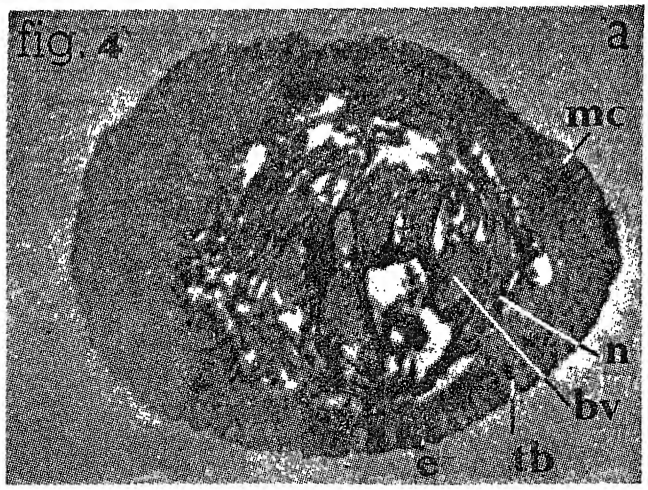


Fig. 4*a*. Transverse section of a barbel.

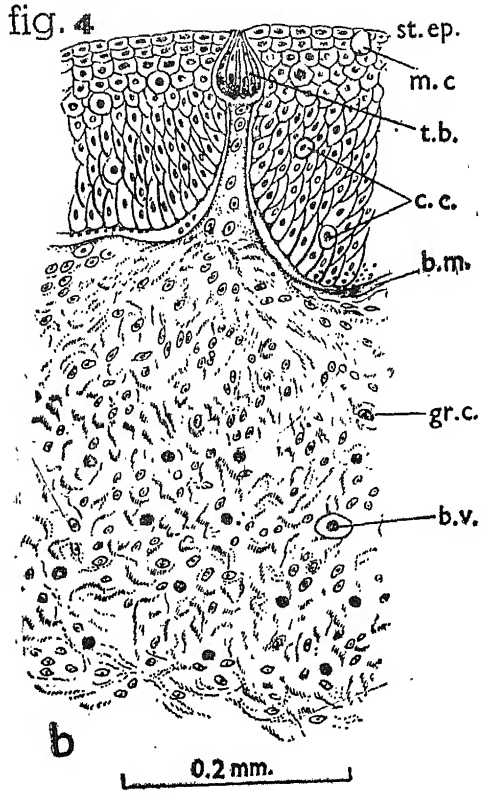


Fig. 4*b*. Transverse section of a Lip.

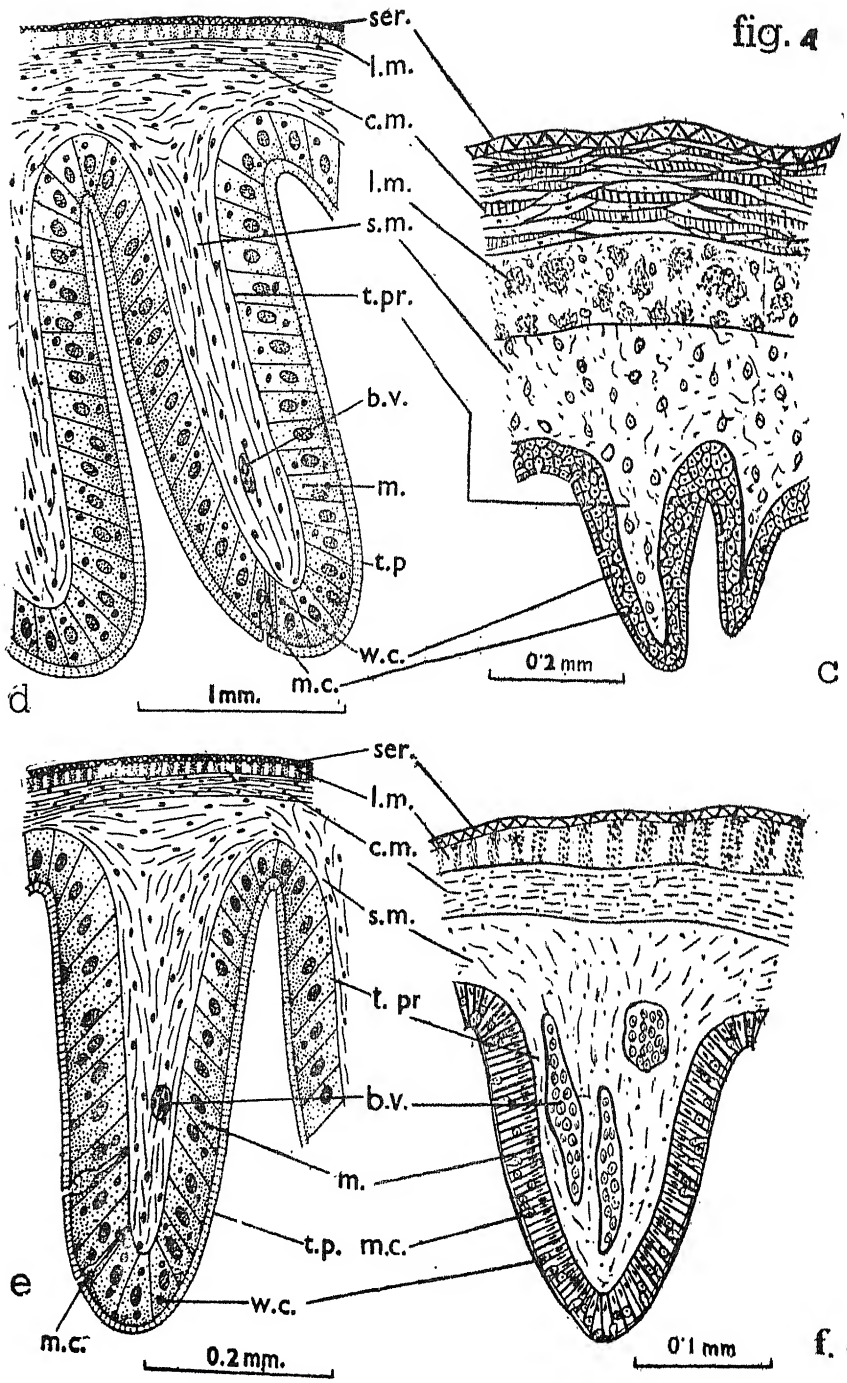


Fig. 4*c*. Transverse section of a Oesophagus.
Fig. 4*d*. Transverse section of a Intestinal swelling.
Fig. 4*e*. Transverse section of a Intestine
Fig. 4*f*. „ „ Rectum.

b.m.—Basement membrane; b.v.—Blood vessel; c c.—Clavate cell; c.m.—Circular muscles; e.—Epidermis; gr.c.—Granulated cell; l.m.—Longitudinal muscles; l.pr.—Lamina propria; m.—Mucosa; m.c.—Mucous cell; n.—Nerve bundle; ser.—Serosa; s.m.—Submucosa; st.ep.—Stratified epithelium; t.b.—Taste bud; t.p.—Top plate; t.pr.—Tunica propria; w.c.—Wandering cell; (a.—X100).

Summary

Tor putitora is an omnivorous fish. It feeds upon green filamentous algae (Spirogyra and Ulothrix), insect larvae, small molluscs, water plants and slimy deposits on the rocks. Its feeding habits, relative length of the gut, morphology and histology of the alimentary canal are in accordance with its omnivorous habit.

(1) Alimentary canal of *Tor putitora* consists of a protrusible mouth and fleshy lips. The mouth leads into a buccal cavity which in turn continues into a pharynx. The pharyngeal teeth are stout and conical. The pharynx, through a short oesophagus, opens into the intestinal bulb. In the anterior part of the intestinal bulb open the bile and pancreatic ducts separately. No multicellulor glands occur in the wall of intestinal bulb. Posteriorly, the intestinal bulb leads into a long and coiled intestine. The last part of the gut runs straight to open to the outside by anus and is called the rectum.

(2) Histologically the wall of the alimentary canal can be differentiated into several layers. The anterior part of the alimentary canal (buccal cavity etc.) is made up of mucosa, sub-mucosa and muscularis and the posterior part (intestinal bulb, intestine and rectum) consists of mucosa, submucosa, muscularis and serosa. Mucous cells occur throughout the alimentary canal but are particularly in abundance in the rectal region.

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The Head-skeleton of Fishes of the Family Synodidae

I. *Saurida tumbil* (Bloch)*

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Introduction

The head-skeleton of synodid fishes has not been studied in detail. The work is on record from Regan (1911), Parr (1929) and Gregory (1933) on certain osteological features of members of the order Iniomi ; Starks (1926) on the ethmoidal region of members of the families Synodontidae and Myctophidae and Awati and Pinto (1937) on the skull of *Harpodon nehereus* (Ham.).** The placement of different synodids has remained controversial and needs confirmation on osteological characters. With this in view the study of head-skeleton of these fishes has been undertaken. De Beer's (1937) terminology has been followed, except for the lower jaw bones, for which the nomenclature from Haines (1937) has been adopted.

Material and Methods

The fish (*Saurida tumbil*) is carnivorous and fairly common along the East and West coasts of Peninsular India. It grows to a length of about 40 cm. Red alizarin transparencies were prepared as suggested by Gurr (1956).

The Skull

The *skull* is superficial, uninterrupted and tropibasic. It is elongated and has feebly developed epiotic and occipital crests. The gape extends up to the occipital region. The symplectics are absent.

The Cranium

The *cranium* is flat and has wide cartilaginous internasal and interorbital septa and prominent subtemporal fossae. The posterior myodome is open behind.

The *ethmoid* is separated behind into the dorsal and ventral plates and it is produced into a small flattened lateral cornu on either side. The space between the two plates is divided into a central and two lateral compartments. The ventral plate has a median fissure for the prevomer. The bone has a nodule in front and articulates with the lateral ethmoids, prevomer, parasphenoid, lachrymals, first suborbitals, premaxillae and palatines. It is overlapped by the nasals and tips of frontals. The *lateral ethmoid* is curved and is partly overlapped by the supraorbital. It has a centrally placed aperture for the olfactory tract. The bone articulates with the ethmoid, frontal, parasphenoid, lachrymal, first suborbital, palatine and entopterygoid. The *nasal* is small, superficial and roofs the

*Part of the Ph.D. thesis of Agra University, Agra.

**The placement of different synodids will be discussed after having studied the head-skeleton of Indian synodids in detail, since no complete account of the head-skeleton of any synodid is on record, even the work of Awati and Pinto (1937) on *Harpodon nehereus* (Ham.) is an incomplete one.

olfactory recess. It articulates with the lateral ethmoid and maxilla and is traversed by the supraorbital lateral line canal. It also overlaps the ethmoid and tip of frontal. The *prevomer* is 'T' shaped and lies below the ethmoid. It consists of the body and stem. The body bears teeth and gives rise to a cornu on either side. The bone articulates with the ethmoid, parasphenoid, maxillae and palatines.

The *frontal* is flat and elongated with a narrow anterior and a broad posterior end. Along the outer edge it has a process, which lies over the sphenotic. The bone has a longitudinal inferior ridge and is traversed by the supraorbital and temporal lateral line canals. Each bone overlaps the ethmoid, parietal, sphenotic and pterotic. The bone articulates with the lateral ethmoid, pleurosphenoid, supraorbital and last suborbital. The *pleurosphenoid* is irregular and contributes to the boundaries of cranial cavity and orbit. It has a notch forming the boundary of trigeminofacial complex fenestra. The bone articulates with the frontal, basisphenoid, parasphenoid, sphenotic and prootic. The *parietal* is flat and rectangular with its anterior margin overlapped by the frontal. The left bone is overlapped by the right. It also articulates with the pterotic and epiotic. The *basisphenoid* is Y-shaped lying surrounded by the pleurosphenoids and parasphenoid. The two dorso-lateral limbs contribute to the lower boundary of the channel for olfactory tracts. The *parasphenoid* is the largest bone of skull extending from the prevomer to basioccipital. It consists of the boat-shaped body and flat stem. The body has a notch behind and the stem, a fissure in front. The bone articulates with the ethmoid, lateral ethmoids, prevomer, pleurosphenoids, palatines, basisphenoid, prootics and basioccipital and is attached to the entopterygoids.

The *supraorbital* is elongated and notched along the inner edge. It articulates with the lateral ethmoid, frontal and lachrymal. The *lachrymal* is triradiate and articulates with the ethmoid, lateral ethmoid, supraorbital and first suborbital. The *suborbitals* are six in number encircling each orbit. The first articulates with the ethmoid, lateral ethmoid and lachrymal, while the sixth lies over the sphenotic articulating with the frontal and pterotic. The lachrymal and suborbitals are traversed by the infraorbital lateral line canal.

The *sphenotic* is comma-shaped and contributes to the boundaries of the orbit and auditory region. It has an outwardly and downwardly directed process and bears a groove for the hyomandibula. The bone is overlapped by the frontal, last suborbital and pterotic and articulates with the pleurosphenoid and prootic. The *pterotic* is flat and has a depression for the supratemporal, a tunnel for the horizontal semicircular canal of internal ear and a groove for the hyomandibula. It is traversed by the temporal lateral line canal. The bone underlies the frontal, overlaps the sphenotic, articulates with the parietal, last suborbital, prootic, epiotic and exoccipital and interdigitates with the opisthotic. The *prootic* is flat and squarish contributing to the lower boundary of trigeminofacial complex fenestra and the inner boundary of auditory region. It has a horizontal plate, which meets its counterpart to form the floor of cranium and roof of posterior myodome. The bone is traversed by the horizontal and anterior vertical semicircular canals of internal ear. It has an aperture for the hyomandibular trunk of facial nerve and articulates with the pleurosphenoid, parasphenoid, sphenotic, pterotic, exoccipital and basioccipital. The *epiotic* forms the postero-dorsal boundary of the region. It has a notched otic process and a tunnel for the posterior vertical semicircular canal of internal ear. The bone is overlapped by the posttemporal and articulates with the parietal, pterotic, opisthotic, supraoccipital and exoccipital. The *opisthotic* is irregular and forms the posteroventral boundary of

the auditory region. It articulates with the epiotic, exoccipital and posttemporal and interdigitates with the pterotic.

The *supraoccipital* has a laterally compressed occipital spine and two posteriorly diverging occipital crests for the semicircular canals of internal ears. It articulates with the epiotics and exoccipitals and is overlapped by the parietals. The *exoccipital* is irregular and has a neural plate and an aperture for the glossopharyngeal and vagus nerves. The neural plates of the two sides bound the foramen magnum. The bone articulates with the pterotic, prootic, epiotic, opisthotic, supraoccipital and basioccipital. The *basioccipital* is rectangular bearing an inferior median channel, which is continuous with the posterior myodome. The bone articulates with the parasphenoid, prootics, exoccipitals and first vertebra.

The *supratemporal* is an ossicle bone and the *posttemporal* gets secondarily fused with the cranium. They are traversed by the temporal lateral line canal.

The Mandibular Arch

The *premaxilla* is elongated and bears several rows of teeth. It forms the upper boundary of the gape, articulates with the ethmoid and is attached to the angular. The *maxilla* is straplike, edentulous and adherent to the premaxilla. It lies excluded from the gape and articulates with the prevomer and palatine. The *palatine* is toothed and articulates with the ethmoid, lateral ethmoid, prevomer, maxilla, entopterygoid, ectopterygoid and parasphenoid. The *entopterygoid* is dagger-shaped with a patch of teeth below. It articulates with the lateral ethmoid, palatine, ectopterygoid, metapterygoid and quadrate and is attached to the parasphenoid. The *ectopterygoid* is elongated and toothed. It is aligned with the palatine and articulates with the entopterygoid and quadrate. The *metapterygoid* is plate-like edentulous and bears a ridge along its outer surface. It articulates with the entopterygoid and quadrate and is overlapped by the hyomandibula. The *quadrate* is stout, comma-shaped and with a condyle for the angular. It is distinguished into the body with a small aperture and the spine with a facet for the preopercle. Between the spine and body lies the distal end of interhyal. The bone articulates with the ectopterygoid, entopterygoid, metapterygoid, angular, hyomandibula and preopercle. The *retroarticular* is a small nodule-like bone ossified at the hind end of angular. The *angular* is arrow-shaped and edentulous constituting one-third of the lower jaw. It has two processes in front and articulates with the retroarticular, quadrate and sesamoid articular. It is also connected with the preopercle by ligaments. The *sesamoid articular* is a small irregular bone ossified along the inner surface of angular. The *dentary* is stout and constitutes two-thirds of the lower jaw. It bears a few rows of depressible teeth. It is broad and forked behind for the angular and narrow in front. The narrow end forms the mandibular symphysis with its counterpart. The angular and dentary are traversed by the mandibular segment of operculomandibular lateral line canal.

The Hyoid Arch

The *hyomandibula* hangs obliquely from the cranium and has a groove all along its posterior edge for the preopercle and an oblique foramen leading into a tunnel on the inner surface for the hyomandibular trunk of facial nerve. The bone articulates with the sphenotic, pterotic, metapterygoid, quadrate, interhyal, opercle and subopercle. The *interhyal* is a small rod-like bone lying along the inner surface of preopercle and suspending the hyoid cornu from hyomandibula. The *epihyal* is flat and elongated lying apposed along the inner surfaces of quadrate

ABBREVIATIONS USED

ang., angular ; bbr-3., third basibranch ; bhy., basihyal ; boc., basioccipital ; brstr., branchiostegal ray : cbr., ceratobranch ; chy., ceratohyal ; dnt., dentary ; dp., dentigerous pad ; dpt., dentigerous plate ; ebr., epibranch ; ecpt., ectopterygoid ; ehy., epihyal ; enpt., entopterygoid ; epo., epiotic : eth., ethmoid : exoc., exoccipital ; fr., frontal ; grk., gill rakers ; hbr., hypobranch ; hhy., hypohyal ; hmd., hyomandibula ; ihy., interhyal ; iop., interopercle ; ipt., infrapharyngeal teeth : lac., lachrymal ; leth., lateral ethmoid ; mpt., metapterygoid ; mx., maxilla ; na., nasal ; op., opercle ; opo., opisthotic : pa., parietal ; pal., palatine ; pbr., pharyngobranch ; pls., pleurosphenoid ; pmx., premaxilla ; pop., preopercle ; pro., prootic ; ps., parasphenoid ; ptro., pterotic ; ptt., posttemporal ; pvo., prevomer ; qu., quadrate ; rta., retroarticular ; sar., sesamoid articular ; so-1 to so-6., suborbitals : soc. supraoccipital ; sop., subopercle ; sph., sphenotic ; spo., supraorbital ; spt., supratemporal.

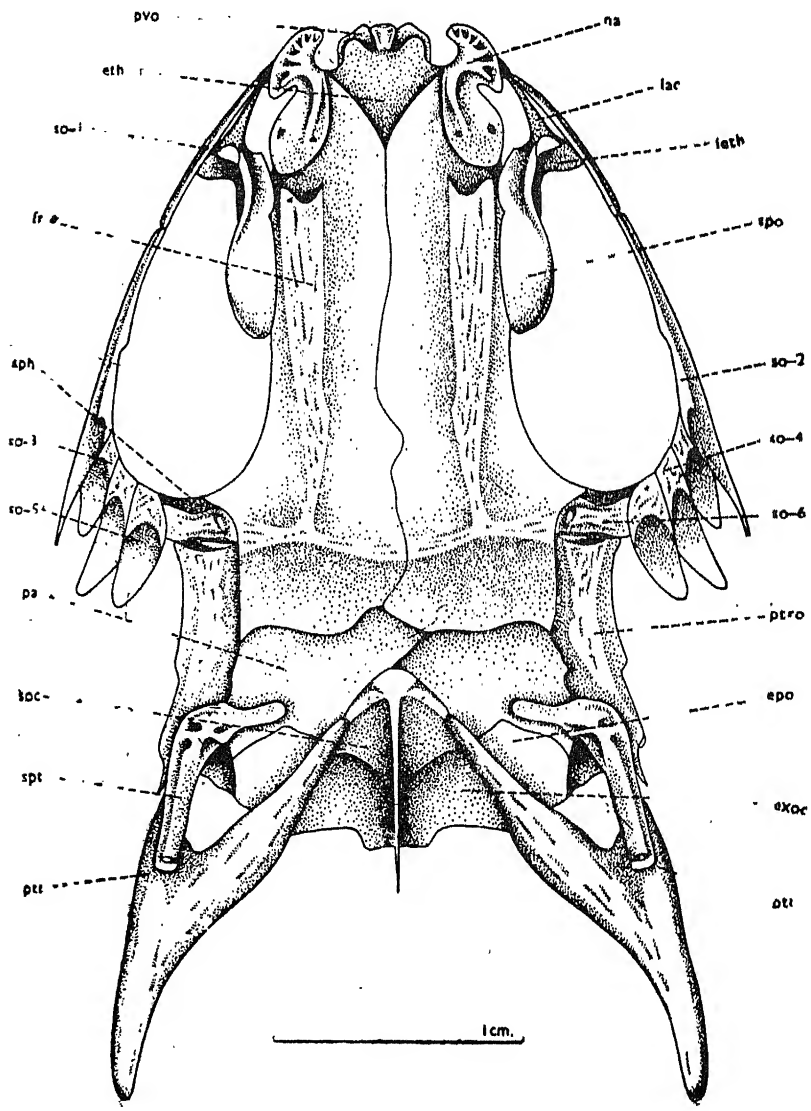

PLATE 1. Dorsal view of cranium.

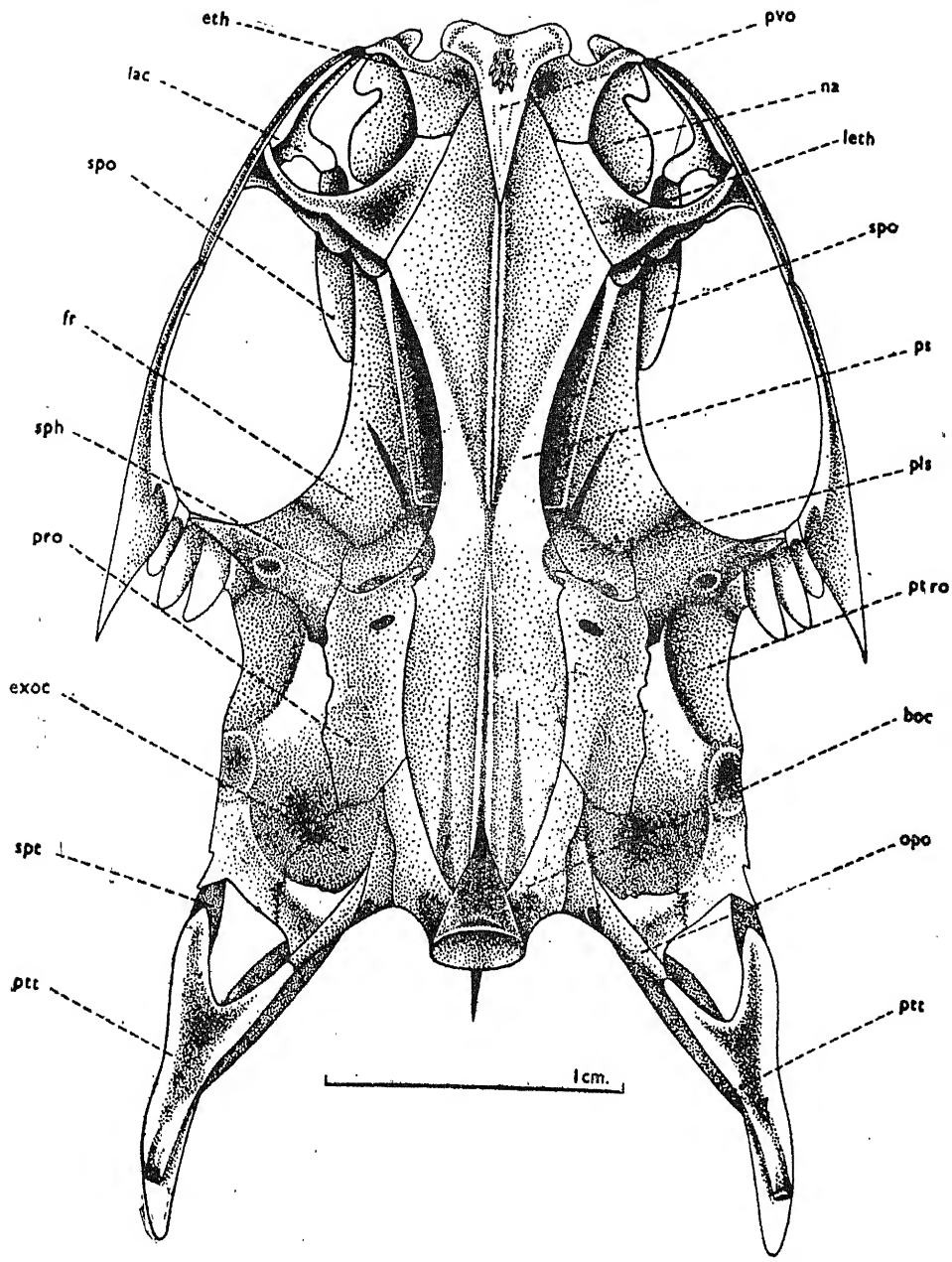

PLATE 2. Ventral view of cranium.

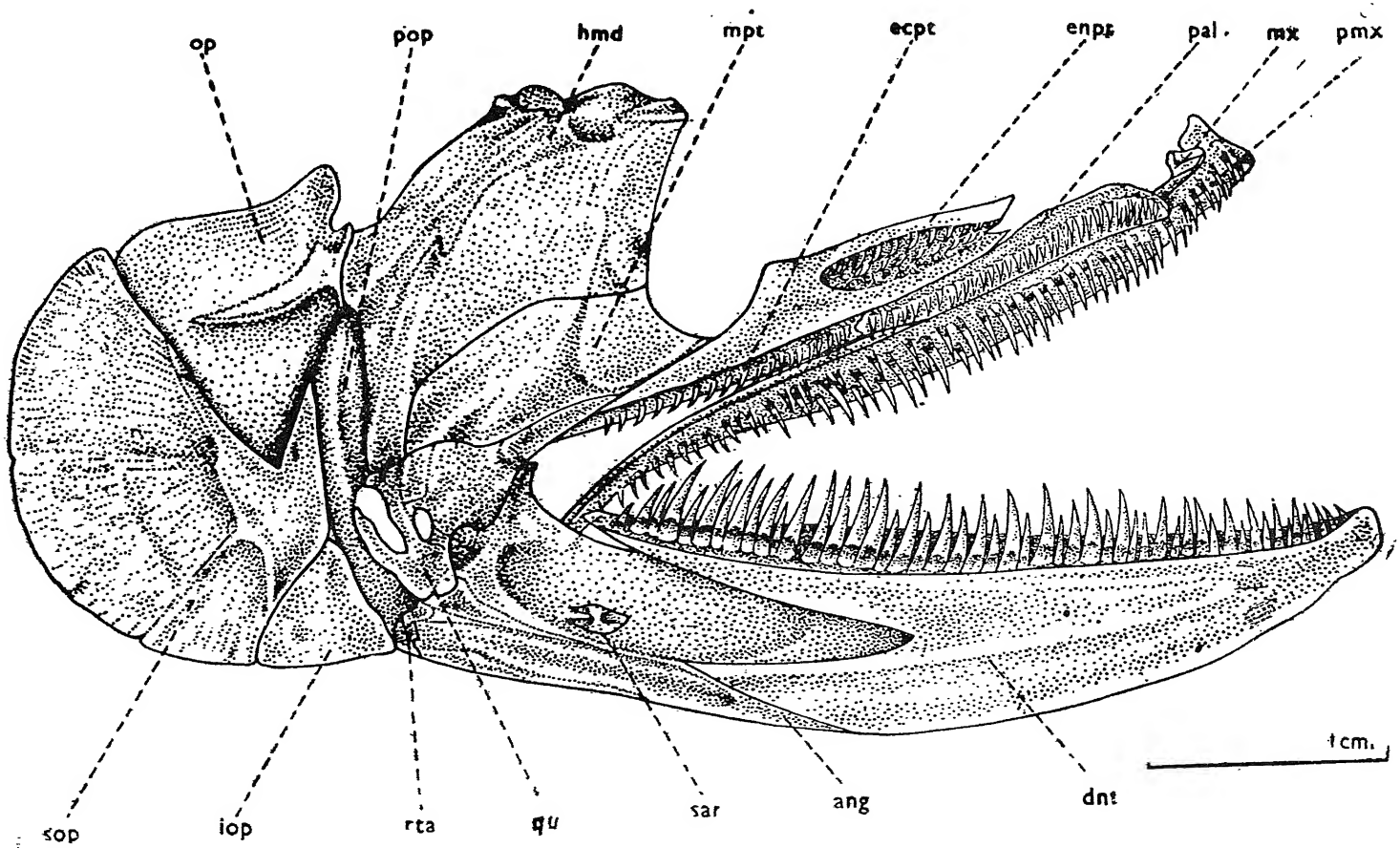

PLATE 3. Inner view of mandibular and hyoid arches.

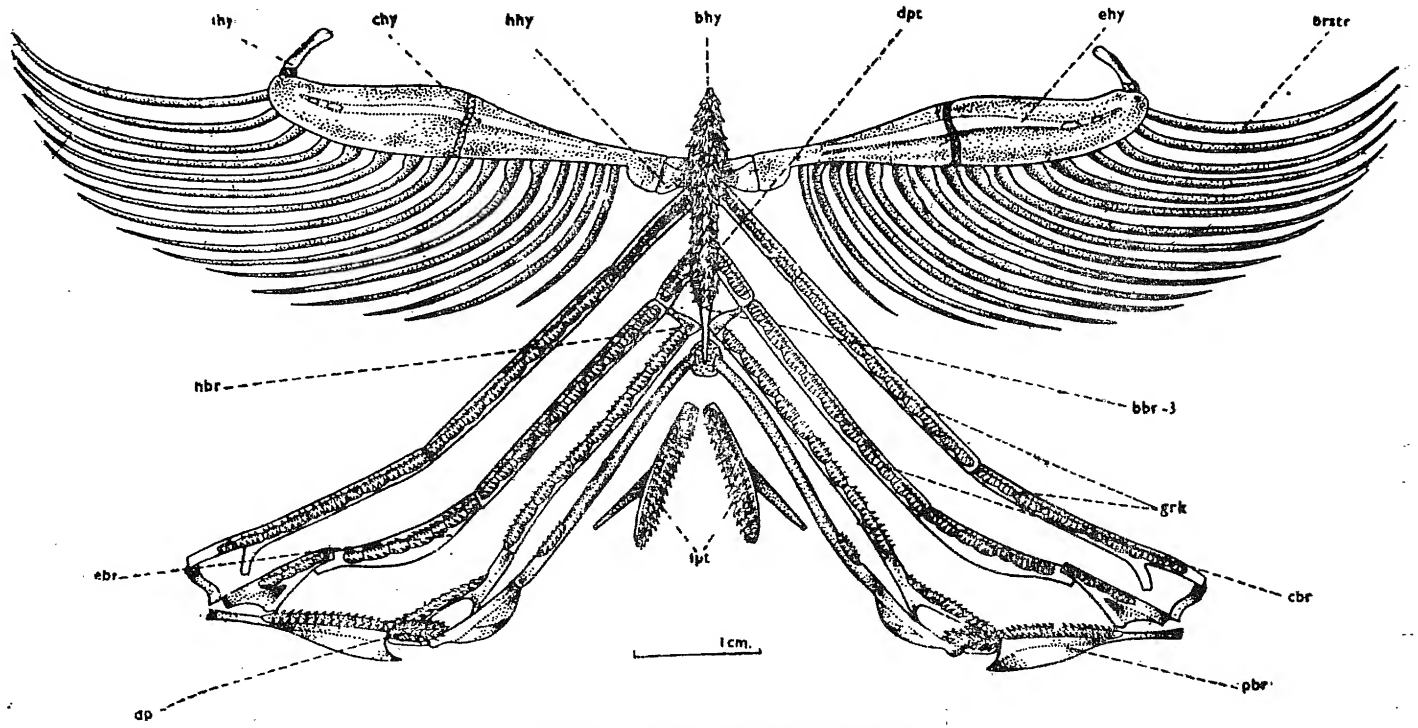

PLATE 4. Hyoid and branchial arches.

and metapterygoid and bearing eight branchiostegal rays. The *ceratohyal* is flat and elongated and also bears eight branchiostegal rays. The *hypohyals* are two small bony pieces placed dorso-ventrally on either side. The upper pieces are smaller than the lower ones and the inner edges of the hypohyals of two sides lie apposed. The *basihyal* is elongated conical and extends in front beyond the hypohyals. It bears short and pointed teeth above. The bone articulates with the upper pair of hypohyals, first basibranch and a dentigerous plate. The *urohyal* is elongated, laterally compressed and bifid in front. It is attached to the cleithral symphysis. The *opercle* is triangular and has a concavity in front for the hyomandibula. It articulates with the subopercle and preopercle. The *subopercle* is the largest bone of the series and is produced in front into a spine, which lies along the inner surface of preopercle. The *interopercle* is triangular and the smallest of the series. The *preopercle* is sword-like and tapering above. It lies in the groove of hyomandibula and is traversed by the opercular segment of the operculomandibular lateral line canal. The bone articulates with the quadrate and hyomandibula and overlaps the rest of bones of the series and symplectic.

The Branchial Arches

The first *pharyngobranch* is curved, second flattened, third triangular and fourth oval. Each of them articulates with the corresponding epibranch and succeeding pharyngobranch. The last two bear a pad of suprapharyngeal teeth. The *epibranchs* are elongated rods and each of the first three bears an uncinate process and gill rakers. The first four *ceratobranchs* are edentulous, rod-like and bear gill rakers. The fifth is like an inverted 'Y' and carries infrapharyngeal teeth. The *hypobranchs* are three in number. The first two are rod-like and aligned with the corresponding ceratobranchs. The third is somewhat comma-shaped and is placed at right angles to the second and third arches. The *basibranchs* are three in number and are covered over by a *dentigerous plate.*

Discussion

The skull is squarish and platybasic in *Harpodon* (Awati and Pinto, 1937), but elongated and tropibasic in *Saurida.* The individual bones are delicate and fragile with muciferous channels in *Harpodon* (Regan, 1911 and Awati and Pinto, 1937), but well ossified and without muciferous channels in *Saurida.* The interorbital septum is absent in *Harpodon* (Awati and Pinto, 1937), but a cartilaginous septum is present in *Saurida.* The palate has a single tooth-band in *Trachinocephalus* (Day, 1878), but two such bands have been observed in *Saurida.*

The ethmoid is complex and lies away from the basisphenoid in *Synodus* spp., *Trachinocephalus* (Starks, 1926) and *Saurida,* but it is simple and lies articulated with the basisphenoid in *Harpodon* (Awati and Pinto, 1937). Starks (1926) noted a few horizontal plates in the ethmoid cartilage in *Synodus,* which have not been found in *Harpodon* (Awati and Pinto, 1937) and *Saurida.* Starks (1926) also noted a median crested ethmoid in *Neoscopelus,* but such a crest is wanting in *Saurida.* The lateral ethmoid is described as the lateral prolongation of ethmoid in *Harpodon* (Awati and Pinto, 1937), while it is a distinct bone in *Saurida.* The olfactory tract does not pass through the lateral ethmoid in *Harpodon* (Awati and Pinto, 1937), but it passes in *Saurida.* The prefrontal (lateral ethmoid) lies remote from the mesethmoid (ethmoid) in *Neoscopelus, Synodus* (Starks, 1926) and *Trachinocephalus* (Gregory, 1933) and *Saurida.* The nasal is a distinct bone in *Synodus* (Starks, 1926), *Trachinocephalus* (Gregory, 1933) and *Saurida,* but it is absent in *Harpodon* (Awati and Pinto, 1937). The prevomer is large and toothed in *Neoscopalus,* absent in *Synodus* and *Trachinocephalus* (Starks, 1926), forked in *Harpodon*

(Awati and Pinto, 1937) and T-shaped and toothed in *Saurida*. Okada (1955), however, reports a toothless prevomer in *Trachinocephalus*.

The frontal is rugose in *Trachinocephalus* (Starks, 1926), sculptured and squarish in *Harpodon* (Awati and Pinto, 1937), but smooth and elongated in *Saurida*. The pleurosphenoid is partly enclosed in the hollow of parasphenoid in *Harpodon* (Awati and Pinto, 1937), but articulated with the parasphenoid in *Saurida*. The parietals are more or less triangular and widely separated from each other in *Harpodon* (Awati and Pinto, 1937), but they are rectangular and overlap in the mid-line in *Saurida*. The parasphenoid is intact in *Synodus* (Starks, 1926), with a cavity in *Harpodon* (Awati and Pinto, 1937), but it has a fissure in front in *Saurida*. The lachrymal is elongated in *Trachinocephalus* (Gregory, 1933) and triradiate in *Saurida*.

The supraoccipital lies partly below and partly behind the parietals in *Trachinocepealus* (Gregory, 1933), between the parietals in *Harpodon* (Awati and Pinto, 1937) and behind the parietals in *Saurida*. The bone has a single median crest in *Harpodon* (Awati and Pinto, 1937), but two diverging crests in *Saurida*. Boulenger (1904) records that the supraoccipital is in contact with the frontals in scopelids, but it has not been found tenable in *Trachinocephalus* (Gregory, 1933), *Harpodon* (Awati and Pinto, 1937) and *Saurida*.

The premaxilla articulates with the palatine in *Harpodon* (Awati and Pinto, 1937), but not in *Saurida*. The maxilla is a distinct bone in *Synodus* (Gregory, 1933) and *Saurida*, but it is absent in *Harpodon* (Regan, 1911, Weber and de Beaufort, 1913 and Awati and Pinto, 1937). The entopterygoid does not articulate with the palatine and quadrate in *Harpodon* (Awati and Pinto, 1937), but it does so in *Saurida*. The sesamoid articular is wanting in *Harpodon* (Awati and Pinto, 1937), but it is present in *Saurida*.

Summary

The skull is superficial, uninterrupted and tropibasic. The cranium is flat and with wide cartilaginous internasal and interorbital septa. The subtemporal fossae are prominent. The palate has two tooth-bands.

The ethmoid is complex and the lateral ethmoid has a centrally placed aperture for the olfactory tract. The nasal is small and the prevomer is toothed. The parietals are overlapping. The suborbital ring has six pieces. The supraoccipital has two diverging crests and the basioccipital has a channel below, which is continuous with the posterior myodome. The maxilla is strap-like and edentulous. The palatine, entopterygoid and ectopterygoid are toothed. The symplectic is absent. The epihyal and ceratohyal bear eight branchiostegal rays each. The hypohyals are in two pairs and placed dorso-ventrally. The basihyal is elongated, conical and toothed. The subopercle is the largest and the interopercle the smallest of the series. The pharyngobranchs and epibranchs are four in number. The last two pharyngobranchs bear suprapharyngeal teeth. The basibranchs are covered over by a dentigerous plate.

Acknowledgements

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Physiological Studies on Red Leaf Disease of American Cotton (*G. hirsutum*) in Utter Pradesh

By

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Eversince the introduction of American cottons, red leaf disease has been a fairly serious problem in all American cotton growing regions of India. A wide scale survey of these cottons made in Uttar Pradesh during 1963-64 revealed that water-logging in fields during the reproductive phase of the cotton crop even for a few days resulted in the development of this disease and in consequent reduction in *kapas* yield. The severity of the disease was observed to be somewhat more in crops grown in poor soils.

For collecting experimental evidence on these observations and for exploring the possibility of ameliorating the disease, investigations were made under controlled conditions of pot culture at Government Cotton Research Station, Raya (Mathura), the results of which are reported in this paper.

Review of literature

Burt and Haider (1919), for the first time, observed red leaf disease in Kanpur American Cottons in Uttar Pradesh. Kottur (1920) from Dharwar, Milney (1921 and 1922) from Punjab, Prayag (1927–28) from Khandesh, Sawhney (1932) from Deccan, Rao and Wad (1936) from Central India and Dabral (1938) from Sind reported this disease to be of common occurrence in American cottons. Dastur and Singh (1947) and Dastur *et. al.* (1952) investigated the red leaf disease in Sind American cottons and in the American cottons grown in the Malwa and Bombay Karnatak tracts respectively. After a critical appraisal of the available literature and the results obtained from his own investigations, Dastur (1959) made the claim that red leaf is a common symptom exhibited by American Upland cottons due to three different causes so far investigated, *viz*; deficiency of nitrogen in Sind-American cottons, maturity of the crop in the Malwa tract and dessicating effect on leaves of the North Easterly Winds that set in December-January in the Karnatak region.

Material and Methods

The experiment was conducted in cement concrete pots of 32 × 31 × 25 cm. size with American cotton, 320F having twelve treatments as under:

Treatments

A— Water-logging

(1) No water-logging—W_0
(2) Water-logging—W_1 (for 18 days)

B—Fertility level

(1) Poor soil (Unmanured sub-soil)—M_0
(2) Rich soil (Soil and F. Y. M. in 2 : 1 ratio)—M_1

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C–Ameliorative N doses

(1) Control (Water sprayed)—N_0

(2) 0·1% N through Urea —N_1

(3) 0·3% N through Urea —N_2

The pots were filled with about 20 kg. air-dried, sieved subsoil or soil plus manure mixture as per treatments under *B* above. The drainage holes of the pots under water logging treatment were sealed with cement for the sake of creating artificial water logging conditions in them. In the last week of April, all the pots were uniformly filled with water and when the soil came in proper tilth, 4 sound seeds of American cotton var. 320F were sown in each pot on 30th April. There were 10 such pots (replicates) in each of the 12 treatments. A month after sowing, thinning of extra seedlings was done so as to leave only one healthy plant in each pot. Watering, hoeing and weeding etc. were done in them according to requirement.

During the active square formation phase in the plants, water logging condition was created with effect from 22nd July and continuously maintained for a period of 18 days. Red leaf disease was produced on the plants during this period. Therefore the first spraying of urea solution was done as per treatments on 17th August and the second spraying on 26th August. At each time, the nutrient solution of requisite concentration containing 0·01% Teepol, a wetting agent, was sprayed @ 10 c.c. fluid per plant. Visual observations on development of the disease and on its amelioration were taken separately for each treatment. As quite a few plants succumbed to the water logging treatment, for uniformity's sake, final yield in each treatment was recorded only from six plants, which was the minimum number of survivals in it. The yield data were then analysed statistically and the results evaluated at 5% probability level.

Results and Discussion

Visual observations, taken during the period of water-logging and also after that (on 10th August) revealed that red leaf disease developed on all the plants grown under poor soil fertility conditions. Its intensity was, however, more apparent in plants subjected to water-logging. In the rich soil series, the disease was observed only in those plants which were subjected to water-logging. It commenced from the lower leaves of the plants and gradually extended to the upper ones. In the beginning, the leaves turned yellow and a large number of reddish spots developed along their margins. Within three days, these spots spread over the entire leaf surface giving a purplish red appearance to them. Eventually, the leaves died and were shed. After the spraying of the nutrient solution, the newly emerged leaves possessed normal green colour and, in a few days, the diseased plants again assumed almost normal appearance with a few leaves on them.

The analysis of variance of *kapas* yields given in table I shows that the effects of fertility level and water-logging as well as their interaction were highly significant Besides, these, the ameliorative treatments also gave a highly significant effect.

TABLE I

Analysis of variance for kapas yield (gm./plant)

Sources of variation	D. f.	m. s. s.	F.
Replication	5	31·38	1·99
Fertility – M	1	1634·97	103·61***
Water-logging – W	1	404·70	25·65***
Amelioration – N	2	90·42	5·73**
M × W	1	428·76	27·17***
W × N	2	25·96	1·65
M × N	2	13·89	—
M × W × N	2	48·61	3·08
Error	55	15·78	

TABLE II

Kapas yield in gm./plant

W / M	Water logging		Average
	W_0	W_1	
M_0	7·46	7·59	7·52
M_1	21·87	12·24	17·06
Average	14·66	9·92	12·29

S. E. for M or W = 0·66 C. D. at 5% for M or W = 1·88
S. E. for M × W = 0·94 C. D. at 5% for M × W = 2·76

Table II reveals that water-logging brought about a significant reduction in *kapas* yield under high fertility while no such effect was observed in the case of poor fertility level of the soil. High fertility status increased the yield of *kapas* significantly both under water-logged and normal soil conditions. These increases were, however, more marked in the latter case. It gave an indication that the nutrient elements present in the fertile soil could not be fully utilised by the plants under water-logged conditions for the production of high yields. The results thus showed that poor soil fertility conditions and water-logging were conducive to the appearance of red leaf disease.

TABLE III

Kapas yield in gm./plant

N / W	Ameliorative N doses			Average
	N_0	N_1	N_2	
W_0	11·70	14·63	17·65	14·66
W_1	8·92	10·12	10·73	9·92
Average	10·31	12·37	14·19	12·29

S.E. for W = 0·66 S.E. for N = 0·81 S.E. for interaction 1·15
C.D. at 5% for W = 1·88 C.D. at 5% for N = 2·30 C.D. for interaction = N.S.

As to the ameliorative treatments, the foliar application of 0·3% N effected a significant increase in yield over that of control (water-sprayed). No significant interaction was, however, observed between spraying and water-logging treatments. It indicated that, although foliar application of nitrogen at the higher concentration had a general beneficial effect on the crop yield, it did not specifically make up for the loss sustained by the plants due to water-logging.

Summary

An experiment was conducted in cement pots under controlled conditions to investigate if poor soil fertility or water-logging or both are responsible for the appearence of red leaf disease in American cottons, and to find out if foliar application of nitrogen could off-set the loss sustained by the crop due to this disease. The results showed that both poor soil fertility and water-logging are conducive to the appearance of this disease. The foliar application of 0·3% N in the form of aqueous solution of urea gave a significant improvement in *kapas* yield. The spraying treatments, however, could not succeed in fully making up for the loss in yield suffered by the crop due to this disease.

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Effect of pre-soaking of potato tubers in Indole-3-acetic acid

By

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Introduction

Soaking of stem pieces in water or solutions, to promote early rooting and better performance, has been an old practice in vegetative propagation. Beneficial effects of auxin action on germination have been reported in water soaked sugarcane setts by Moir (1922), Martin (1939), and Singh and associates (1964) and others.

Increased water uptake by potato discs, under the influence of IAA was reported by Reinders (1942), Hackett and Thimann (1950, 1952 , and Levitt (1948). Reinders reported an initial lag of two days before the effect of IAA on water uptake and respiration rate of potato discs was noticeable. Respiratory and growth responses to externally applied IAA have been reported by many workers.

In the present investigations, emphasis has been laid on the physiological changes in the seed tubers as influenced by soaking in IAA solutions of varying concentrations. The impact of these changes on rooting, sprout formation and early seedling growth has been examined critically.

Methods and Materials

Healthy potato tubers (*var.* Military special) were selected for experimentation. Equal sized potato tubers, after being thoroughly washed in water, were cut longitudinally so that both the halves possessed approximately equal number of 'eyes'.

The halves were immersed in aqueous solutions of 10, 50, 100 and 200 ppm concentrations of Indole-3-acetic acid. Cut tubers soaked in distilled water served as control. The soaking period in each case lasted for 12 hours after which the tuber pieces were washed in water.

The tuber pieces were sown 5 cm deep in fired clay butamin painted pots filled with acid washed sand and arranged in randomised block design. Each treatment consisted of six pots with 5 tuber pieces per pot.

For the determination of water uptake by tuber tissue, the cut halves were weighed, numbered, and immersed in IAA solutions of the above mentioned concentrations, accompanied by an usual series of control. Water uptake was determined by the increase in the fresh weight of tuber pieces at the end of the soaking period. Carbohydrate content and tissue moisture of unsoaked tubers was determined.

Observations pertaining to both qualitative as well as quantitative changes were made at weekly intervals, beginning from the 7th day after sowing. The

mother tubers of two pots of each treatment and also of the control, selected at random, were taken out by carefully washing the sand with a fine jet of water over fine mesh iron netting. Five cuttings, selected at random from each treatment, with intact roots and sprouts were subjected to growth studies as well as to the physiological changes in the seed tubers. Observations pertaining to qualitative growth changes included sprout number, root length, and sprout length.

The quantitative growth changes included the determination of fresh and dry weight of mother tubers ; tuber-tissue moisture (moisture per 1 gm dry weight of tubers), percent decrease in dry weight of the treated tubers over unsoaked ones, and fresh weight of sprouts as well as roots and the amount of dry weight therein calculated on % basis.

Other tubers were subjected to chemical analyses for starch content, reducing and non-reducing sugars by Fehling's method (Loomis and Shull, 1937). The data were analysed by Fisher's (1950) method of analysis of variance.

Experimental Findings

Water uptake : Water uptake by potato tubers at the end of 12 hour steeping period, expressed as percent increase over unsoaked tubers was markedly, yet identically, influenced in both the control as well as the treated series. Statistically the effect remained insignificant (Table 1).

TABLE 1

Effect of pre-soaking of potato tuber pieces in different concentrations of IAA, on the water uptake by tubers

Percent increase in water uptake by treated over unsoaked tubers						S.E.	C.D. 5%	C.D. 1%
Concentration (ppm)	0	10	50	100	200			
Increase at the end of 12 hrs	20·70	20·71	20·71	20·72	20·72	N.S.		

Number of sprouts : IAA application had no significant effect on sprout number at any of the three stages of observation (Table 2).

Sprout length : During the early stages, *i.e.* 7th day, the sprout length was insignificantly affected by IAA application. Later on (*i.e.* 14th and 21st day age) significant responses were found. On the 14th day, although the overall treatment effect was significant, the treatments varied insignificantly among themselves (Table 2). Only 200 ppm of IAA, which registered minimum growth, proved significantly inferior as compared to others. On the 21st day of age IAA had significantly improved the sprout length. Higher concentrations of 100 and 200 ppm proved significantly less effective than lower concentrations of 10 and 50 ppm ; the latter being optimum (Table 2).

Root length : During the early stages of growth IAA significantly suppressed root length. On the 14th day, however, an entirely changed pattern of root

length was observed. The overall treatment effect was insignificant with comparatively better root growth in lower concentrations of 10 and 50 ppm of IAA. Higher concentrations of 100 and 200 ppm still lagged behind in this respect (Table 2). This changed pattern of root growth was carried still further so much so that on 21st day the inhibitory effect of IAA was not only overcome but changed to a stimulatory one. Highest concentration of 200 ppm (Table 2) proved best in increasing the root length.

TABLE 2

Effect of pre-soaking of potato tuber pieces in different concentration of IAA on sprout number, sprout length and root length

Characters	Average per tuber piece					S.E.	C.D. 5%	C.D. 1%
Sprout number								
Concentration (ppm)	0	100	50	10	200			
7th day	2·4	2·0	1·6	1·6	1·0	N.S.	–	–
Conc. (ppm)	0	100	10	50	200		–	–
14th day	2·6	2·0	2·0	1·6	1·0	N.S.	–	–
Conc. (ppm)	0	10	50	100	200			
21st day	2·6	2·0	2·0	2·0	1·5	N.S.	–	–
Sprout length (cm)								
Conc. (ppm)	50	10	0	200	100			
7th day	2·14	2·02	1·94	1·78	1·62	N.S.	–	–
Conc. (ppm)	50	10	0	100	200			
14th day	6·72	6·36	6·30	6·28	4·80	0·158	0·47	N.S.
Conc. (ppm)	50	10	100	200	0			
21st day	16·8	15·0	15·0	14·4	12·6	0·406	1·222	N.S.
Root length (cm)								
Conc. (ppm)	0	10	50	100	200			
7th day	2·40	1·58	1·32	1·32	1·26	0·630	1·890	3·005
Conc. (ppm)	50	10	0	100	200			
14th day	12·84	12·50	12·10	11·38	10·60	N.S.	–	–
Conc. (ppm)	200	100	50	10	0			
21st day	28·0	24·7	23·9	21·9	17·8	2·66	8·006	N.S.

ppm denotes : parts per million.

Sprout weight : Both fresh weight and dry weight (calculated on percentage basis) of sprouts were markedly influenced by IAA application. All the levels of IAA registered significant increase in fresh weight of sprouts at all the three stages of observation and it was recorded that higher the concentration of IAA,

greater was the fresh weight of sprouts (Table 3). The dry matter accumulation in sprouts (Table 3) was not affected in the like manner and it was rather interesting to record greater dry matter accumulation in treatments which registered minimum linear growth of sprouts (Table 3, 21st day).

Root weight : Pattern of quantitative root growth showed a striking parallel with that of qualitative growth responses. Since it was noticed that during the early stages of seedling growth the treated series registered significantly lower fresh weight values and dry matter percentage, but on the 21st day, however, all concentrations of IAA significantly increased both fresh weight and percentage dry matter accumulated (Table 3).

TABLE 3

Effect of pre-soaking potato tuber-pieces in different concentrations of IAA on fresh weight and Dry weight calculated on percent basis of roots and Sprouts

Fresh weight (gm) of sprouts per 5 tuber pieces						S.E.	C.D. 5%	C.D. 1%
Conc. (ppm)	200	100	50	10	0			
14th day	3·215	2·525	2·002	1·850	1·788	0·0019	0·0058	0·0082
Conc. (ppm)	200	100	50	10	0			
21st day	8·220	7·710	6·454	5·012	4·616	0·0019	0·0057	0·0090
Dry weight of sprouts calculated on percent basis								
Conc. (ppm)	200	100	50	10	0			
14th day	9·72	8·63	8·00	7·90	7·80	0·07	0·21	0·33
Conc. (ppm)	200	100	50	10	0			
21st day	10·00	9·98	9·78	8·87	8·14	0·0033	0·0099	0·0157
Fresh weight (gm) roots per 5 tuber pieces								
Conc. (ppm)	0	10	50	100	200			
14th day	4·47	4·13	4·08	4·04	4·01	0·0019	0·0058	0·0093
Conc. (ppm)	200	100	50	10	0			
21st day	9·525	8·926	8·563	7·825	7·627	0·0002	0·0007	0·0011
Dry weight of roots calculated on percent basis								
Conc. (ppm)	0	10	50	100	200			
14th day	5·313	4·190	3·363	3·261	3·001	0·011	0·042	0·066
Conc. (ppm)	200	100	50	10	0			
21st day	6·25	5·94	5·01	4·95	4·75	0·004	0·014	0·022

Tuber moisture : No significant variations, with respect to tuber moisture per gm of dry matter, were recorded at the end of 12 hours steeping period. From the 7th day onwards, however, IAA treated tubers showed significantly higher water content as compared to control. The water content of the tuber pieces increased progressively with increasing IAA concentrations as well as with advancing seedling age (Table 4).

Tuber weight : The application of Indole-3-acetic acid showed insignificant variations in respect of percent decrease in dry matter of treated over unsoaked tubers at the end of 12 hours soaking period (Table 4). From the 7th day onwards all the treated series recorded significantly decreased percentage of dry weight of seed tubers. On the 21st day, however, higher concentrations of 100 and 200 ppm of IAA, although significantly superior to others, remained insignificant among themselves (Table 4).

TABLE 4

Effect of pre-soaking of potato tuber pieces in different concentrations of IAA on dry weight and moisture content of the seed tubers

% decrease in D.W. of soaked tubers over unsoaked tubers						S.E.	C.D. 5%	C.D. 1%
Conc. (ppm)	200	100	10	50	0			
After 12 hrs of soaking	0·023	0·023	0·023	0·022	0·022	N.S.	–	–
Conc. (ppm)	200	100	50	10	0			
7th day	11·12	10·69	10·50	8·96	4·06	0·67	2·01	3·205
Conc. (ppm)	200	100	50	10	0			
14th day	12·32	11·72	11·62	10·69	7·73	0·008	0·025	0·040
Conc. (ppm)	200	100	50	10	0			
21st day	12·85	12·59	11·89	10·88	9·62	0·46	1·39	2·20
	Tuber moisture (moisture per gm D.W.)							
Conc. (ppm)	200	100	50	10	0			
After 12 hrs of soaking	4·502	4·502	4·501	4·501	4·500	N.S.	–	–
Conc. (ppm)	200	100	50	10	0			
7th day	11·748	11·225	10·947	9·263	5·720	0·0019	0·0057	0·0090
Conc. (ppm)	200	100	50	10	0			
14th day	14·267	12·986	12·931	11·225	7·977	0·938	2·82	4·47
Conc. (ppm)	200	100	50	10	0			
21st day	15·611	14·924	13·326	11·516	9·810	0·686	2·06	3·27

Starch : A consistant and highly significant decrease in starch content of the treated tubers was noted. This depletion of starch was intensified with the increase in IAA concentration as well as with advance in seedling age (Table 5).

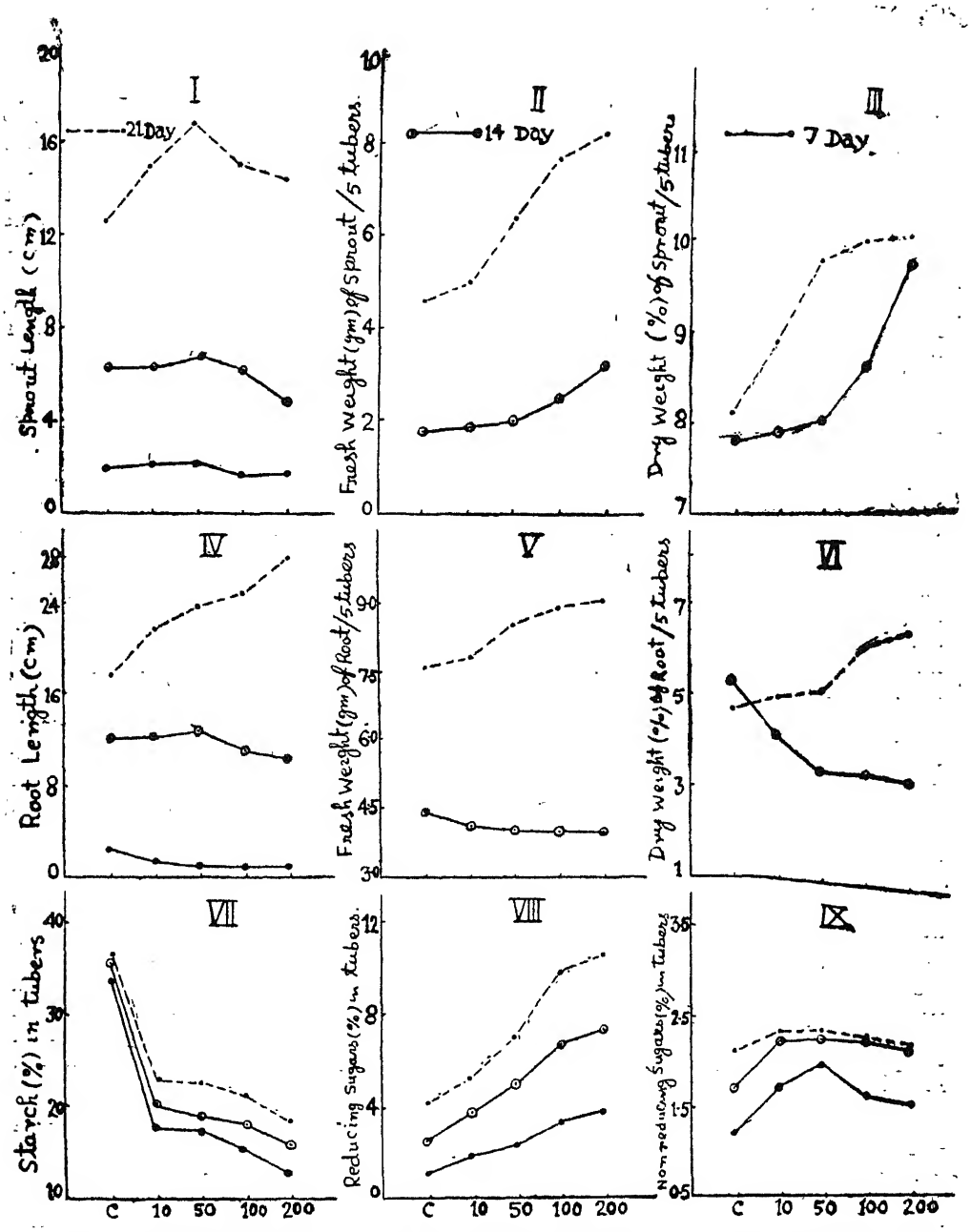
Reducing sugars : Highly significant increase in the reducing sugar content of the treated tubers was recorded with the increase in IAA concentrations and age of the seedling (Table 5).

Non-reducing sugars : Non-reducing sugar content of the seed tubers was rather peculiarly influenced by IAA. While maximum non-reducing sugar content was recorded in 50 ppm series, the response to other treatments could be arranged as 10, 100, 200 ppm, and control in decreasing order of effectiveness ; the treatments however, varying significantly over control as well as among themselves at all the three stages (Table 5).

TABLE 5

Effect of pre-soaking of potato tuber pieces in different concentrations of IAA on carbohydrate reserves of the seed tubers

Carbohydrates	% values on D.W. basis					S.E.	C.D. 5%	C.D. 1%
Starch								
Conc. (ppm)	0	10	50	100	200			
7th day	36·81	22·81	22·61	21·13	18·75	1·568	4·719	7·479
Conc. (ppm)	0	10	50	100	200			
14th day	35·95	20·20	19·01	18·25	15·75	1·82	5·47	8·68
Conc. (ppm)	0	10	50	100	200			
21st day	34·25	18·25	18·02	15·22	12·72	0·49	1·47	2·33
Reducing sugars								
Conc. (ppm)	200	100	50	10	0			
7th day	3·806	3·362	2·378	1·888	1·075	0·0004	0·0012	0·0019
Conc. (ppm)	200	100	50	10	0			
14th day	7·489	6·741	4·931	3·724	2·488	0·70	2·70	3·33
Conc. (ppm)	200	100	50	10	0			
21st day	10·638	9·939	7·112	5·202	4·189	0·0047	0·0143	0·0162
Non-reducing sugars								
Conc. (ppm)	50	10	100	200	0			
7th day	1·900	1·756	1·663	1·548	1·242	0·0019	0·0057	0·0090
Conc. (ppm)	50	10	100	200	0			
14th day	2·234	2·226	2·207	2·188	1·706	0·0019	0·0057	0·0090
Conc. (ppm)	50	10	100	200	0			
21st day	2·378	2·364	2·229	2·193	2·145	0·0047	0·0141	0·0224



IAA Concentration in ppm. IAA Concentration in ppm. IAA Concentration in ppm.

Effect of pre-soaking of Potato tuber pieces in different concentrations of Indole-3-acetic acid on (I) Sprout Length, (II) Fresh Weight of Sprout, (III) Dry Weight of Sprout, (IV) Root Length, (V) Fresh Weight of Root, (VI) Dry Weight of Root, (VII) Starch (% of D.W) in tubers (VIII) Reducing Sugars (% of D, W,) in tubers, (IX) Non-reducing Sugars (% of D, W.) in tubers

Discussion

That water uptake by potato discs is an aerobic process has been demonstrated by many workers. Reinders (1942) reported an initial lag of two days before the effect of IAA on water uptake as well as on respiration rate of potato discs could be noticed. This delayed action of auxin on water uptake and respiratory activity (calculated by the decrease in dry weight) of the seed tubers was also confirmed by these investigations. The measurement of dry weight changes in seed tubers during the entire course of the present investigations presented a clue as to the rate of respiratory activity, since it was recorded that the treated tubers lost comparatively more of their food reserves than the control.

The loss in dry weight of seed tubers was strikingly reflected in the changed pattern of growth. The results presented herein support the findings of Commoner and Thimann (1941) that higher concentrations of IAA, (*viz.* 100 and 200 ppm), inhibited the linear growth of sprouts (Fig. 1), and even on 21st day of age higher concentrations of IAA, although superior to control, still proved comparatively inhibitory to the linear growth of sprouts, but the percent loss in dry matter of the seed tubers, decreased with increase in IAA concentration. It may, thus, be concluded that the parallelism between respiration and IAA–stimulated growth is rather limited since higher concentrations of IAA retarded growth without a concomittant decrease in the dry matter content of the seed tubers.

Roots presented quite a different response to auxin application. During the early stages of seedling development IAA proved deleterious to root length and also to root weight (Figs. 4–6). But latter this inhibitory effect was not only overcome, but changed into a stimulatory one (Figs. 4–6, 21 day age). These findings are in close parallelism with those of Thimann and Lane (1938) in case of corn roots.

At 21st day of age (Figs. 5–6) auxin appeared to be responsible for the production of heavier root system. The increased rate of translocation of the metabolites from the light-loving parts, their subsequent storage in the light avoiding parts, and the stimulated production of profuse lateral root system might possibly have been the contributory factors in the production of heavier root system. Deposition of starch in the root cap primordia which resulted from treatment of tomato cuttings with IAA as shown by Bausor (1942) could be taken as an evidence in favour of the storage of metabolites in the roots. The pattern of quantitative shoot growth was rather peculiary affected by IAA. Greater accumulation of dry matter was recorded with higher concentrations of IAA which, in turn, proved inhibitory rather than stimulatory to the linear growth of the light-loving part of the seedling (*i.e.* shoot). This finding was in conformity with those of Kandler (1953), who has shown that the production of dry matter may even be increased by auxin concentrations which inhibit the growth in length.

The carbohydrate reserves of the mother tubers showed an interesting response to IAA applications (Fig. 6–9). A close correlation existed between the depletion of starch and decrease in dry matter of the seed tubers. This could be interpreted to mean that depletion of starch was correlated with the auxin stimulated respiratory activity. This depletion of starch was in conformity with the findings of Bausor (1942) and of Mitchel, Whitehead and Muriel (1940), in intact tomato stems and bean leaves respectively. The enhanced rate of starch depletion suggested the possibility of stimulated amylase and diastatic activity of the treated tubers. Such a mobilisation of respiratory reserves by IAA was reported by Anker (1953). A comparatively higher diastatic activity was, however,

reported in 2, 4-D treated bananas than in corresponding controls by Freiberg (1955).

Under the action of auxins, usually sugars were induced to be accumulated at the expense of starch reserves as was also noted by Thompson (1945) and Bausor (1942). In the present investigations comparatively more reducing sugars accumulated in the treated series (Fig. 8). This increased accumulation of reducing sugars suggested an increased rate of invertase activity, causing thereby an accelerated breakdown of non-reducing sugars, as reported by Smith (1941).

The interesting feature of the present study was that both reducing (Fig. 8) and non-reducing sugars (Fig. 9) in the seed tubers increased with the advance in the duration of the experiment. During the early stages of growth, comparatively less accumulation of sugars suggested a correspondingly faster utilization than during the later stages. The possibility that, during the early stages of seedling emergence the mother tubers would have served as the only source of food reservoir, can not be ruled out. With the development of leaves and roots the draw on the reserve food of the mother tubers by the young sprouts lessened so that the increased accumulation of sugars resulted.

Summary

The effect of pre-soaking of potato tuber pieces in different concentrations of aqueous IAA solutions on sprouting, rooting, early seedling growth and physiological changes in the seed tubers was studied. IAA did not exert any significant influence on the number of sprouts As regards the sprout length, somewhat inhibitory effect was noticed during the early stages (*i.e.* 7th day) of seedling growth. Later on (*i.e.* 21st day of age), the sprout length was significantly increased, the lower concentrations IAA being comparatively more effective than the higher ones. The depressive effect of IAA on root length during the early stages of growth changed later into a stimulatory one. The quantitative root growth paralleled that of qualitative growth. But in case of the shoot the qualitative and quantitative growths were not identically influenced, since higher values of dry matter accumulation were recorded even in concentrations that inhibited growth in length.

A progressive and highly significant decrease in starch content of the seed tubers was noted in the treated series as compared to control. IAA application also stimulated an increased accumulation of reducing and non-reducing sugars.

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On a New Cestode, *Oochoristica delhiensis* n.sp., from the common Wall Lizard *Hemidactylus flaviviridis* (Ruppel) from Delhi (India)

By

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The cestodes collected from the intestine of the common wall lizard *Hemidactylus flaviviridis* (Ruppel) from Delhi, belong to the genus *Oochoristica* Luhe 1898, of the subfamily Anoplocephalinae Blanchard, 1891, (Family Anoplocephalidae Cholodkovsky, 1902).

Oochoristica delhiensis n.sp.,

(Plate 1 Fig. 1 and 2 ; Plate 2 Fig. 3 and 4)

Description (all measurements in mm.)

The worms measure 100 × 0·396. Scolex 0·264 × 0·264, distinctly demarcated from the strobila. Suckers unarmed, oval to spherical, 0·088 – 0·132 × 0·066 – 0·132. Neck prominant 1·76 long. Proglottids acraspedote. Anterior immature proglottids broader than long, posterior immature ones considerably longer than broad, 0·110 – 0·770 × 0·242 – 0·352. Mature proglottids longer than broad, 0·880 – 1·32 × 0·352 – 0·593. Gravid proglottids also longer than broad, 1·05 – 1·76 × 0·37 – 0·503. Segmentation indistinct posteriorly. Ventral and dorsal excretory canals 0·005 in width.

Proterandrous. Testes follicular, 28 – 39 in number, situated posterolateral to vitelline gland, rarely extend beyond the ventral excretory canals laterally. Testes measure 0·03 – 0·06 in diameter. Ovary, 0·166 – 0·330 wide, bilobed, each lobe with several short lobules. Vitelline gland compact, 0·06 – 0·176, postovarian and variously shaped. Mehlis gland, 0·044 – 0·110 wide. Genital openings irregularly alternate, located near the posterior end of the anterior half of the proglottid margin. Genital atrium, 0·125 – 0·175 wide and 0·066 – 0·088 deep. Cirrus sac oval, 0·154 – 0·220 × 0·066, extends obliquely anteriorwards and is well past the poral excretory canal. Vas deferens much coiled outside the cirrus sac and not surrounded by glandular cells. Vaginal opening posterior to the cirrus sac. Vagina surrounded by glandular cells, not distinguishable into copulatory and conducting regions. Receptaculum seminis small, 0·03 – 0·045 × 0·02 – 0·25. Uterus replaced by egg capsules quite early. Egg capsules 0·04 × 0·03 – 0·04 in diameter. Onchospheres, 0·03 in diameter. Each capsule with a single onchosphere.

Discussion

A comparision with the reported species reveals that the present form comes closer to *O. indica* Mishra, 1945, *O. truncata* Krabbe, 1879 and *O. tuberculata* Rudolphi, 1819.

ABBREVIATIONS

c.s., cirrus sac ; *e.c.*, egg capsules ; *g.a.*, genital atrium ; *m.g.*, mehlis gland ; *n.*, neck ; *ob.*, ovary ; *p.*, premordia of cirrus sac ; *r.s.*, receptaculum seminis ; *s.*, sucker ; *t.*, testes ; *v.*, vagina ; *v.d.*, vas deferens ; *v.g.*, vitelline gland ; *v.e.c.*, ventral excretory canal ; *u.g.*, unicellular gland.

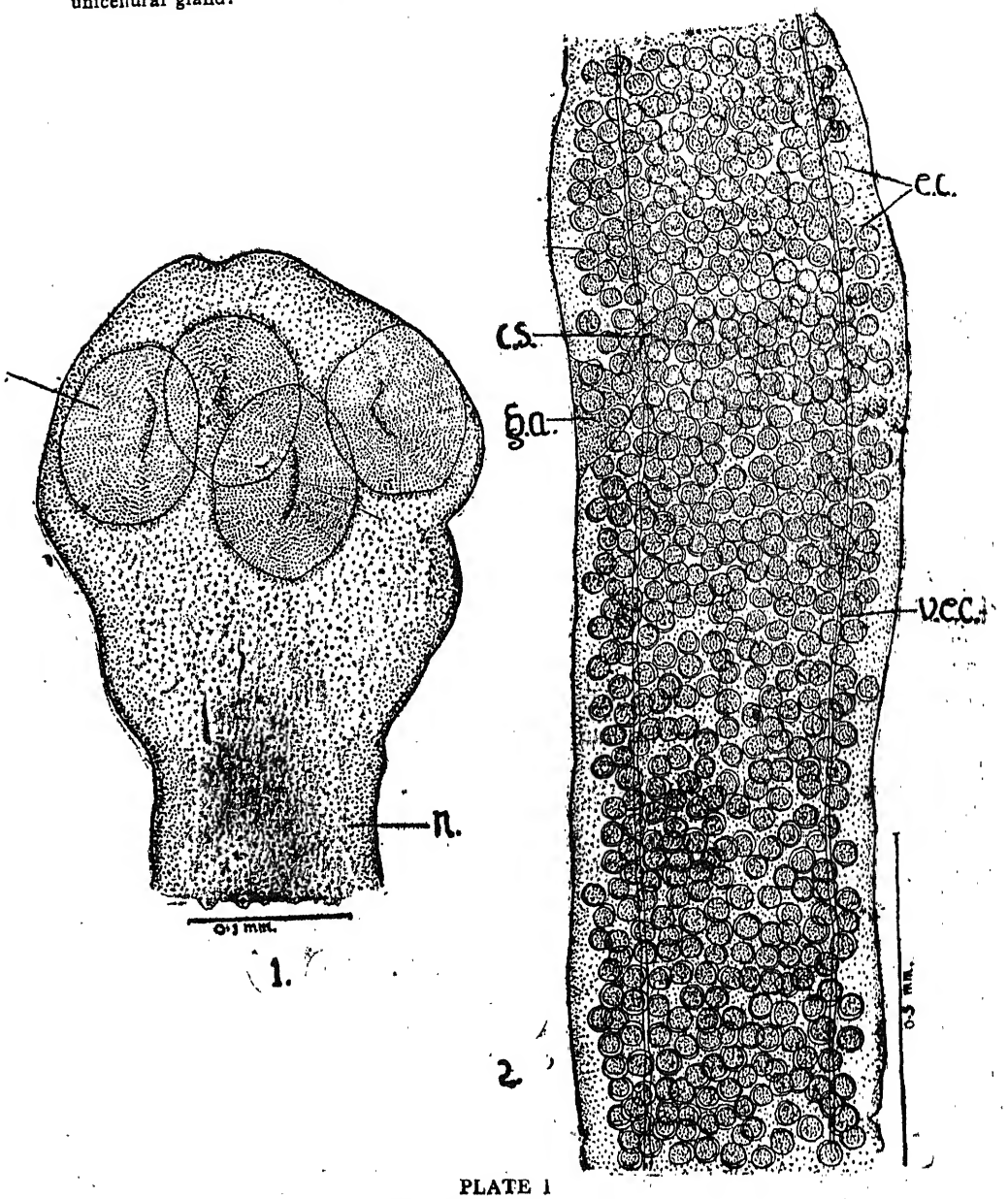

PLATE 1

Fig. 1. Scolex with neck X378 ; Fig. 2. Gravid Proglotti X120

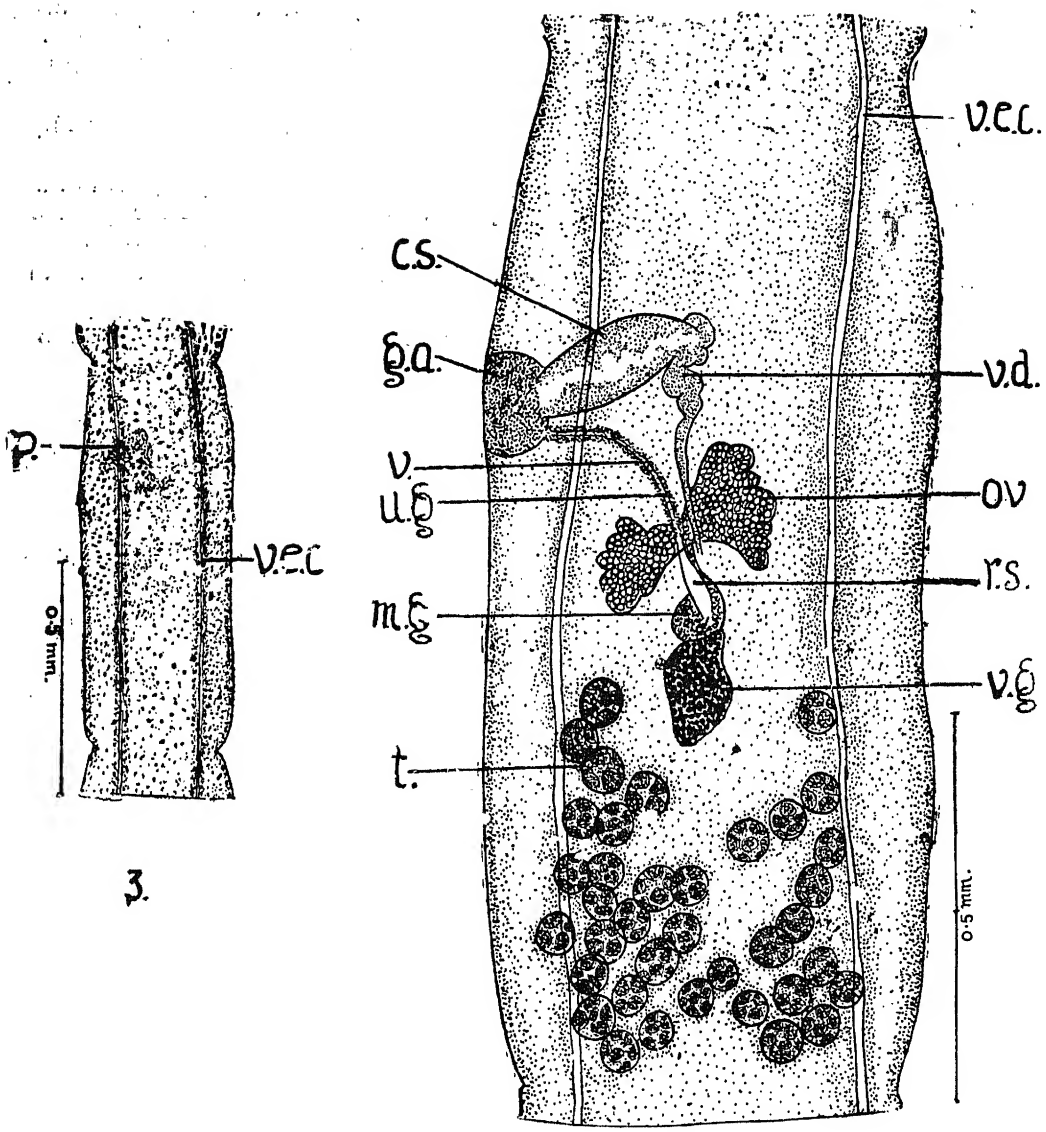

PLATE 2

Fig. 3, Immature proglottid X60 ; Fig. 4, Mature proglottid X120.

The present form differs from *O. indica* in having smaller scolex, suckers, ovary and in having a receptaculum seminis. From *O. truncata* Krabbe, 1879 it differs in having a receptaculum seminis, small egg capsules and in the extent of cirrus sac. *O. tuberculata* Rudolphi, 1819 appears to be most closely related species but the two differ as under :

1. In *O. tuberculata* the immature proglottids are short, the mature ones are square or transversely extended while the present form possesses considerably longer than wide posterior immature, mature and gravid proglottids.
2. The glandular cells surrounding the vas deferens in *O. tuberculata* are totally wanting in the present form.
3. Vagina not distinguishable into copulatory and conducting regions in the present form as is in *O. tuberculata.* Moreover the vagina in the present form is surrounded by glandular cells but not in case of *O. tuberculata.*
4. The receptaculum seminis is present in the present form while absent in *O. tuberculata.*

It is thus proposed to accomodate the present form as a new species *O. delhiensis* n.sp.

Acknowledgment

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Studies on Trematode parasites of Madhya Pradesh Part—I Family Cephalogonimidae Nicoll (1915) Part—I. Three new species of the genus *Cephalogonimus* Poirier 1886

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Introduction

Poirier (1886) created the genus Cephalogonimus to receive a new distom *Cephalogonimus lenoiri* from the intestine of a fresh water turtle *Tetrathyra vaillantii*, with the genital opening at the extreme anterior end. Looss (1899) recorded the type species from another turtle host *Trionyx nilotica* from Egypt. In the same paper Looss created another genus *Leptalea* (= *Emoleptalea* Looss, 1900) with similar position of the genital opening and included both these genera in the subfamily Cephalogoniminae established by him. Nicoll (1915) raised the subfamily Cephalogoniminae Looss (1899) to the family level without giving any dignostic characters and included the subfamily Prosthogoniminae Luhe (1899) in it. He (Nicoll, 1924) reversed this arrangement by raising the subfamily Prosthogoniminae to the family level and in a later paper (1926) he considered both these families as synonyms. Odhner (1911) after discussing the systematic position, came to the conclusion that the genus *Prosthogonimus* Luhe (1899) belonged to the family Lepodermatidae. Poche (1925) followed Odhner (1911) in asigning the genus *Prosthogonimus* to the family Lepodermatidae and accepted the family Cephalogonimidae Nicoll (1915) for the genera *Caphologonimus* and *Emoleptalea* (= *Leptalea*, preoccupied, Looss, 1899) Looss (1900).

Pande (1932) expressed the view that the characters of the family Cephalogonimidae are mostly similar to the family Lepodermatidae (= Plagiorchiidae) excepting the genital opening at the extreme anterior end and hence proposed to reduce the family Cephalogonimidae Nicoll (1915), to its original subfamily rank Cephalogoniminae Looss (1899). Dawes (1946), Yamaguti (1958) and others accepted the validity of the family Cephalogonimidae Nicoll (1915). Skrajbin (1950) removed *Cephalogonimus minutus* (Mehra, 1937) from the genus *Cephalogonimus* and created a new genus *Paracephalogonimus* to receive it.

Synonymy

Looss (1899) created the subfamily Cephalogoniminae for the two genera *Cephalogonimus* Poirier (1886) and *Emoleptalea* (= *Leptalea* preoccupied Looss, 1899) Looss, 1900. Poche (1926) Sinha (1932) and Gupta (1951) regarded the two genera as synonymous while Bhalerao (1936), Mehra (1937), Dollfus (1950) and Yamaguti (1958) regarded them as separate on the basis of the differences in the excretory system.

Chandler (1923) pointed out the similarity between *C. retusus* (Dujardin, 1845) Odhner (1910) and *C. europaeus* Blaizot (1910). Stunkard (1924) supported

this view. Travossus (1932) and Bhalerao (1936) also expressed similar views. Bhalerao (1936) also pointed out the identical nature of *C. gangeticus* Pande (1932) and *C. magnus* Sinha (1932) and further held the latter as similar to *C. amphiumae* Chandler (1923). Cabellero and Sokoloff (1936) in the earlier pages of their paper accepted *C. europaeus* as synonym of *C. retusus* but in the latter pages of the same paper held *C. europaeus* as a valid species.

Lent and Freitas (1940) accepted *C. europaeus* as a valid species. Bhalerao (1942) discussed the nature of the characters used for distinguishing the species of the genus *Cephalogonimus* and pointed out the distinct nature of *C. mehrai* and *C. minutus*. He also revised his earlier opinion (1936) and accepted *C. magnus* as distinct from *C. amphiumae*, but regarded the former as a larger variety of *C. emydalis* Moghe (1930).

Gupta (1954), Yamaguti (1958) and Rai (1961) have accepted the views of Cabellero and Sokoloff (1936) and Lent and Freitas (1940) in regarding *C. europaeus* as a valid species. While Gupta and Rai have followed Bhalerao (1942) in regarding *C. gangeticus* and *C. magnus* as synonym of *C. emydalis* Moghe (1930), Yamaguti (1958) has maintained *C. magnus* as a distinct species and has only accepted *C. gangeticus* as the synonym of *C. magnus*.

During the collection of parasites from fresh-water turtles three new froms were collected along with *C. emydalis* Moghe, 1930, ann *C. mukerjius* Rai, 1961 and are described here.

Cephalogonimus gogatei sp.n. (Fig. 1).

Two fresh water turtles *Trionyx hurum* collected from a tank near Katangi, 20 miles from Jabalpur, were found parasitised by 10 worms, six in one and four in the other host. The worms have elongated body, broad in the anterior half and tapering to a narrow rounded end posteriorly. The cuticle is armed with minute spines directed posteriorly. The number of spines in the second half is meagre. The oral sucker is subterminal, rounded measuring :* 0·095–0·148 in breadth 0·095–0·148 in length. The mouth leads into a small but distinct prepharynx measuring 0·019–0·038. The pharynx is muscular with a wavy anterior margin. It measures 0·0342-0·0532 in length and 0·0532–0·0646 in breadth. A small oesophagus measuring 0 0266–0·0456 follows the pharynx, and leads into two caeca which extend upto the posterior margin of posterior testes or slightly further. The ventral sucker is smaller than the oral sucker and measures 0·0775–0·114 in breadth and 0·0779–0·117 in length and is situated at a distance of 0·364–0·493 from the anterior end.

The testes are postovarian, rounded to oval in shape, oblique and placed in the middle third of the body. The anterior testis is submedian at the equatorial level and usually smaller than the posterior testis. It measures 0·121–0·193 in length and 0·121–0·159 in breadth. The posterior testis is median and situated in the posterior part of the middle third of the body. The vas efferens arises from the outer anterolateral margin of each testis and unite at the base of the cirrus sac. The latter is elongated, clubshaped and extends from the middle of the oral sucker to the anterior half of the ventral sucker. The proximal part of the cirrus sac contains the bipartite vesicula seminalis, pars prostatica and lies obliquely in front of the ventral sucker. The distal part of the cirrus sac is narrow and tubular and contains ductus ejaculatorius and an eversible unarmed cirrus. The genital opening is dorsal to the oral sucker and lies on the right side of the oral opening.

*All measurements are in millimeters.

The pre-equatorial ovary is posterolateral to the ventral sucker and its anterolateral part may overlap the latter. The ovary is oval to round measuring 0·102–0·152 in length and 0·095–0·133 in breadth. The oviduct arising from the inner anterolateral margin of the ovary, joins the ootype, situated on the posterolateral side of the ventral sucker, opposite to the ovary. The receptaculum seminis is posterior to the ovary. The vitellaria are follicular, consisting of a small number of large follicles. The follicles commence between the intestinal bifurcation and the ventral sucker and extend upto the posterior margin of the anterior testis. The vitelline reservoir is triangular and is placed in front of the anterior testis. Its duct opens into the ootype situated immediately in front of it. The uterus occupies the posterior portion of the body, behind the gonads and has few coils with a small number of eggs. The eggs measure 0·0342–0·0380 in length and 0·0152 in breadth.

Relationship

Twenty two species of the genus *Cephalogonimus* have been described so far and twenty of these have been held valid. *Cephalogonimus gogatei* sp.n, resembles *C. europaeus* Blaizot, 1910, *C. mukerjius* Rai, 1961, and *C. apolaimus* Heymann, 1905, in having the submedian genital opening dorsal to the oral sucker. It differs from *C. brevicirrus* Ingles, 1932, *C. americanus* Stafford, 1902, *C. parvus* Oguro, 1941 in the genital opening being median though dorsal to oral sucker. It also differs from *C. amphiumae* Chandler, 1923, *C. thomsi* Dollfus, 1950, *C. emydalis* Moghe, 1930 (Syn. *C. gangeticus* Pande, 1932, and *C. magnus* Sinha, 1952) ; *C. burmanicus* Chatterji, 1936, *C. kumarus* Gupta, 1954, *C. mehrai* Pande, 1932 *C. restusus* (Dujardin, 1845) Odhner, 1910, all having genital opening anterior to oral sucker. *C. compactus* Stunkard, 1924 and *C. japonicus* Ogata, 1934 have oral sucker equal to ventral sucker and *C. lenoiri* Poirier, 1886 and *C. manchuricus* Oguro, 1941, have the oral sucker smaller than ventral sucker and the presently described form *viz. C. gogatei* sp.n. differs from all these species in this character. It also differs from *C. mukerjius* and *C. apolaimus* in having oblique testes, a short but distinct oesophagus, position of gonads and disposition of vitallaria. With its oblique testes the new species resembles *C. europaeus*, but differs from it in the extent of vitellaria, sucker ratio and the size of the eggs. The new species is named after late Prof. B. S. Gogate (Ex-Head of the Department of Zoology, Holkar College, Indore).

Cephalogonimus jabalpurensis sp.n. (Fig. 2).

Eight parasites were found in the intestine of the freshwater turtle *Trionyx hurum* purchased from the local market. The parasites belong to the genus *Cephalongonimus* but differ from the species recorded earlier and hence are described here as new species.

The worm is tounge shaped and measures 1·326–1·89 in length and 0·391–0·544 in maximum breadth behind the intestinal bifurcation. The anterior end is somewhat broader than the posterior. The body wall, in the anterior portion upto the intestinal bifurcation, is sparsely covered with spines. A distinct preoral lobe measuring 0·0380–0·0684 is present. The subterminal oral sucker is oval to rounded, measuring 0·129–1·171 in breadth and 0·129–0·59 in length. The mouth leads into a very small prepharynx which is followed by globular pharynx measuring 0·049–0·076 by 0·057–0·0646. The oesophagus is small and broad and measures 0·019–0·022 in length. It bifurcates into two caeca at a distance of 0·247–0·311 from the anterior end. The caeca extend some distance beyond the posterior testis and 0·255 short of the posterior end of the body.

The postacetabular testes are rounded to oval, tandem or slightly oblique. The anterior testis is equatorial or postequatorial measuring 0·098–0·152 in length and 0·129–0·190 in breadth, The posterior testis is median, immediately behind the anterior testis, with intertesticular space present or absent. It measures 0·114–0·152 in length and 0·119–0·176 in breadth. The large cirrus sac measuring 0·665–0·874 in length and 0·076–0·114 in breadth extends from the anterior end to nearly the posterior margin of the ventral sucker. The bipartite seminal vesicle has a large proximal portion and a small distal portion, followed by the prostatic complex occupying the rest of the broad portion of the cirrus sac. The latter forms a notch behind the pharynx, runs parallel to the pharynx for some distance, and then curves round the oral sucker to open in the genital opening. This narrow part of the cirrus sac contains the ductus ejaculatorius and unarmed eversible cirrus. The genital opening is dorsal and in front of the oral suckar in the preoral lobe.

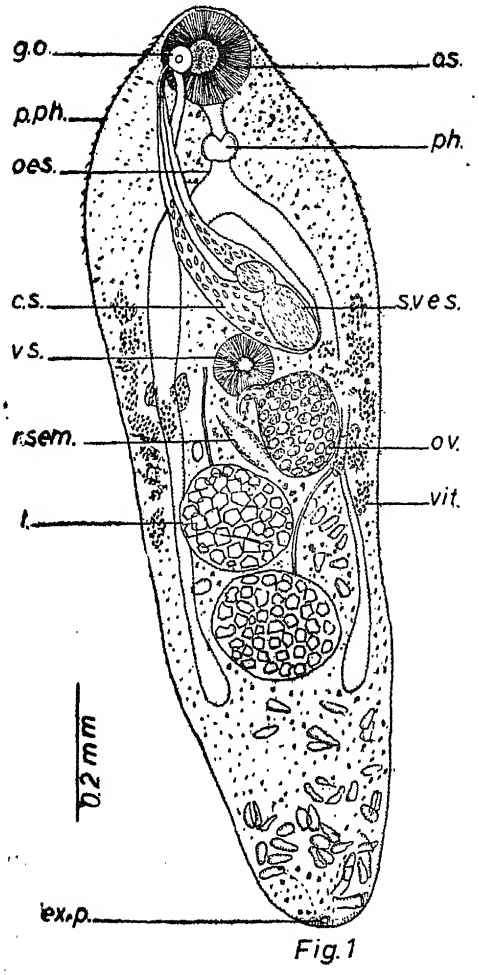
The submedian ovary is pear-shaped, pre-equatorial or equatorial and posterolateral to the ventral sucker. It is round to oval, measuring 0·076–0·129 in length 0·076–0·125 in breadth. The receptaculum seminis lying behind the ovary is usually cresentic. Its duct along with the oviduct joins the ootype which is lateral to ovary. The vitelline follicles are large and extend from the anterior level of ventral sucker to the region between the posterior margin of posterior testis and caecal ends. The follicles which are mostly extracaecal send a pair of transverse ducts in the region of the ovary to the vitelline reservoir which sends a duct to the ootype. The uterus descends upto posterior end and then ascends from the opposite side and extends upto the anterior extremity. There are many transverse coils in the uterus with a large number of eggs measuring 0·0304–0·0380 by 0·0152–0·0190.

Relationship

Cepalogonimus jabalpurensis sp.n. has oral sucker larger than the ventral sucker and thus differs from *C. compactus* Stunkard (1924), *C. japonicus* Ogata (1934), *C. lenoiri* Poirier (1886), and *C. manchurius* Oguro (1941), which have oral sucker smaller or equal to the ventral sucker. In having the genital opening in front of the oral sucker it differs from *C. brevicirrus* Ingles (1932), *C. americanus* Staffard (1932), *C. parvus* Oguro (1941). *C. europaeus* Blaizot (1910), *C. mukerjius* Rai (1961), *C. apolaimus* Heymann (1905) and *C. gogatei* sp.n. *C. jabalpurensis* sp n. resembles *C. indicus* Gupta (1954), *C. retusus* (Dujardin, 1845) Odhner, (1911) and *C. asiaticus* Gupta, 1954 in having the oral sucker larger than ventral sucker and genital opening being in front of the oral sucker but differs from all these in having longer intestinal caeca, extending in the post-testicular region. *C. amphiumae* Chandler (1923), *C. thomsi* Dollfus (1950), *C. emydalis* Moghe 1930) (Syn. *C. gangeticus* Pande, 1932 and *C. magnus* Sinha, 1932). *C. burmanicus* Chatterji (1936) and *C. kumarus* Gupta (1954), resemble the new species in the oral sucker being larger than ventral sucker, position of genital opening and the extent of the intestinal caeca. *C. jabalpurensis* sp.n. differs from *C. burmanicus* and *C. kumarus* in having tandem testis and from *C. emydalis* and *C. burmanicus* in having a distinct oesophagus. It also differs from *C. amphiumae* and *C. thomsi* in the caecal length, extent of vitellaria, body size, sucker ratio, the position of the ventral sucker and gonads. In view of these differences the new species *Cephalogonimus jabalpurensis* sp.n. is created to receive the parasite.

KEY TO LETTERS

c., cirrus : c.s., cirrus sac ; cm., caecum ; g.c., gland cells ; ex.p., excretory pore ; oes., oesophagus ; o.s., oral sucker ; ov., ovary ; p.p. pars prostatica ; t., testis ; ut., uterus ; vit., vitellaria ; v.s., venral sucker ; v.sem., vesicula seminalis.



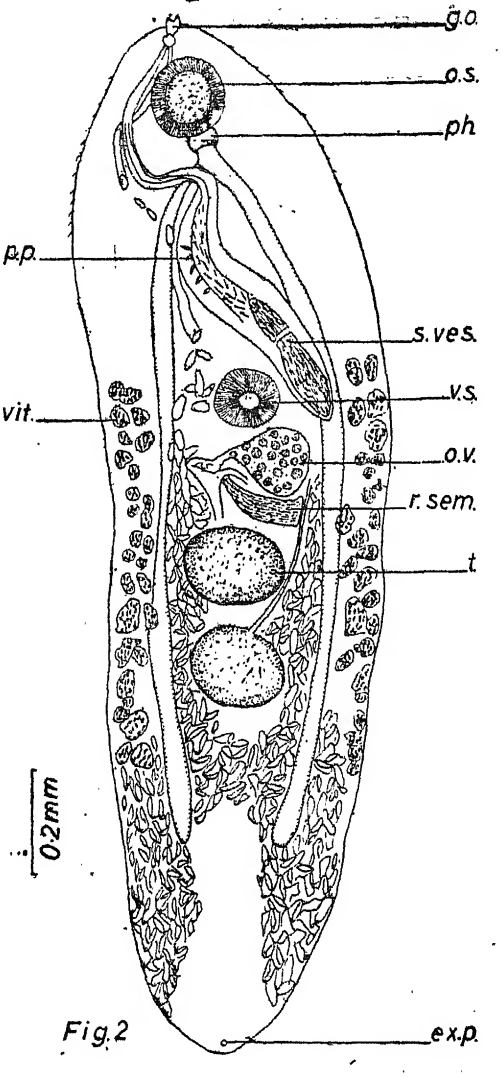


Fig. 1. *Cephalogonimus gogatei* sp.n.

Fig. 2. *Cephalogonimus jabalpurensis* sp.n.

Cephalogonimus moghei sp.n. (Fig. 3)

Three freshwater turtles *Trionyx hurum* from Sadar Tank in Jabalpur were examined for the parasite infection. Only one of them was infected with three worms described here. The worms in the living condition were whitish and were associated with five specimens of *C. mukerjius* Rai (1961). Measurements of only two specimens are recorded as the third is slightly damaged and those in bracket pertain to smaller specimen.

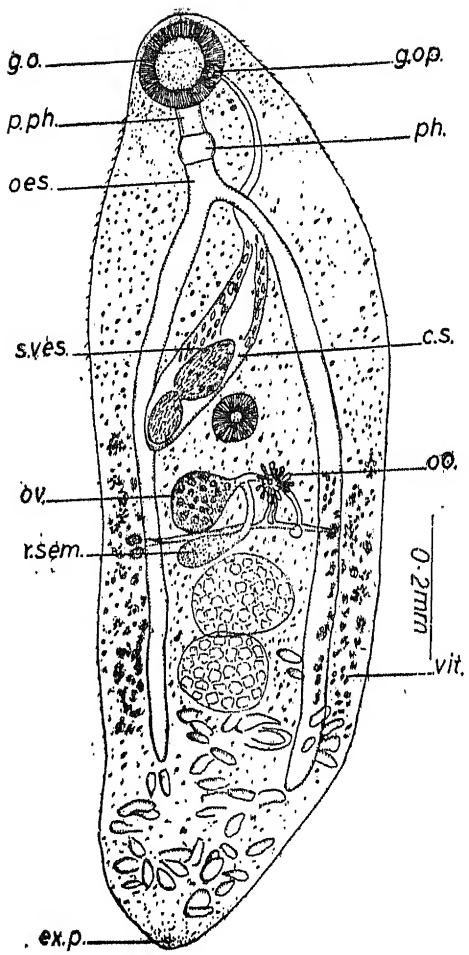


Fig.3

Fig. 3. *Cephalogonimus moghei* sp.n.

The parasites are small measuring 1·292 (0·901) in length and 0·408 (0·340) in breadth. Minute spines pointing outwards cover the anterior quarter of the body. The oral sucker is subterminal rounded and measures 0·117 in diameter (0·114). The well developed prepharynx follows the mouth and measures 0·0266 in length (0·019). The pharynx is muscular and globular measuring 0·0456 by 0·0570 (0·019 by 0·019). A small oesophagus measuring 0·038 in length leads the pharynx and bifurcates, at a distance of 0·287 in front of the ventral sucker, into two caeca which extend beyond the posterior testis, situated in the posterior part of the third quarter. The ventral sucker is smaller than oral sucker and is placed slightly anterior to the equator, 0·527 from the anterior extremity. It measures 0·083 in breadth and 0·045 in length (0·095 dia.).

The postequatorial testes are oblique with smooth margin. They are situated in the third quarter of the body. The anterior testis is submedian,

measuring 0·0987 in length and 0·171 in breadth (0·076 by 0·095), while the median posterior testis measures 0·114 in length and 0·127 in breadth (0·076 by 0·076). The broad proximal portion of the cirrus sac is situated obliquely behind the intestinal bifurcation, with its basal end touching the middle level of the ventral sucker. It contains bipartite seminal vesicle. The distal part of the cirrus sac is narrow, tubular, contains the ductus ejaculatorius and protrusible cirrus and extends upto the oral sucker. The genital opening is dorsal to the oral sucker and on the right side of the mouth.

The female genital organs consist of an equatorial, pretesticular, submedian ovary measuring 0·095 in length and 0·083 in breadth (0·075 × 0·095). The receptaculum seminis is oblong and is preceded by the ovary while the shell-gland complex is lateral to the ovary. The vitellaria extend from the anterior part of the ventral sucker to slightly behind the posterior margin of the posterior testis. The follicles are small and arranged in number of rows. Most of the follicles are extracaecal. The uterus occupies the region behind the gonads and has a small number of eggs measuring 0·026–0·034 by 0·0152–0·0190.

Relationship

Cephalogonimus moghei sp.n. is the fourth species to be described from Jabalpur. It has oral sucker larger than the ventral sucker, genital opening dorsal and submedian and resembles in these characters with *C. europaeus* Blaizot (1910) *C. mukerjius* Rai (1961), *C. apolaimus* Heymann (1905) and *C. gogatei* sp.n. and differs from all other species in these characters. It differs from *C. apolaimus* in having oblique testes, genital opening being on the right side of the mouth and presence of the oesophagus. The new species differs from *C. mukerjius* in having a small oesophagus, in the position of the cirrus sac (not beyond the ventral sucker) and the disposition of vitellaria. From *C. europaeus* it differs in the extent of the vitellaria and the egg size. It also differs from *C. gogatei* sp.n. in the shape of the body, the position of the gonads, extent of the cirrus sac, the disposition of vitellaria and the size of the eggs. The species is named after Late Dr. M. A. Moghe of Nagpur.

Key to the species of the genus, *Cephalogonimus* Poirier (1886).

	Oral sucker equal to the ventral sucker	...	I
	Oral sucker smaller than ventral sucker	...	II
	Oral sucker larger than ventral sucker	...	III
I	Testes obliquely placed, rounded ; vitellaria extend from a little in front of ventral sucker to the ends of the intestinal caeca ; ovary and cirrus touching the ventral sucker	...	*C. compactus* Stunkard, 1924
	Testes tandem in position ; cirrus sac extends a little beyond the ventral sucker	...	*C. japonicus* Ogata, 1934
II.	Oesophagus present	...	A1
	Oesophagus absent	...	A2
A1.	Measures maximum 3 mm. in length; vitelline follicles smaller in size, extracaecal and extend from the middle of ventral sucker to the posterior end of posterior testes ; ovary and cirrus sac touching the ventral sucker	...	*C. lenoiri* Poirier, 1886

Measures 3·85–4·71 mm. in length ; vitelline follicles bigger in size ; overlapping the intestinal caeca ; ovary and cirrus sac not touching the ventral sucker. ... *C. manchuricus* Oguro, 1941.

A2. Testes transversely elongated, obliquely placed ; vitellaria below the border of intestinal bifurcation upto the posterior end of posterior testis ; cirrus sac and ovary touching the ventral sucker. *C. vesicaudus* Nickerson, 1912.

III. Intestinal caeca terminate in the post-testicular field. ... B1

Intestinal caeca do not terminate in the post testicular field but in the testicular field ... B2

B1. Genital pore sub-terminal on the dorsal side of the oral sucker ... b1

Genital pore not on the dorsal side of the oral sucker but in front of it ... b2

b1. Genital pore median ... (*i*)

Genital pore not median *i.e.* to the right side of the median line. ... (*ii*)

(*i*) Caudal vesicle and a small vesicle in each vas efferens present. ... *C. brevicirrus* Ingles, 1932

Caudal vesicle and a small vesicle in each vas efferens absent ... (*i*) *a*

(*i*) *a* Testes obliquely placed ; ovary and cirrus sac touching the ventral sucker. ... *C. americanus* Stafford, 1932.

Testes tandem, transversely elongated ; only cirrus sac touching the ventral sucker and not the ovary. *C. parvus* Oguro, 1941.

(*ii*) Testes obliquely placed ; vitelline follicle extend from the posterior region of oral sucker upto the posterior end of posterior testis ; cirrus sac does not extend beyond the level of ventral sucker ; ovary overlapping ventral sucker ... *C. europaeus* Blaizot, 1910.

Testes obliquely placed; vitelline follicles extend from between intestinal bifurcation and ventral sucker to anterior half of anterior testis, genital opening lateral to mouth and dorsal to oral sucker ... *C. gogatei* sp. n

Testes tandem ; Oesophagus present ; slender and long ; genital pore at the right side of the oral sucker at the level of the mouth opening ... *C. mukerjiius* Rai, 1961.

Testes tandem, oesophagus small and stout ; cirrus sac not extending beyond ventral sucker, vitellaria extending from anterior region of ventral sucker to beyond posterior margin of posterior testis, genital opening dorsal to oral sucker on right side of mouth opening. ... *C. moghei* sp. n.

Testes tandem ; oesophagus absent ; genital pore right to the median line at the level of pharynx ... *C. apolaimus* Heymann, 1905

b2. Testes tandem in position ... (*iii*)

Testes oblique in position ... (*iv*)

(*iii*) Oesophagus present ... (*iii*) *a*1

Oesopuagus absent ... (*iii*) *a*2

(*iii*) *a*1. Vitellaria extend just behind the anterior end of the ventral sucker to the level of the posterior testis, on the left side the follicles are more extensive ; intestinal caeca extend nearly to the posterior extremity of the body ... *C. amphiumae* Chandler. 1923

Vitellaria extend from some distance anterior to ventral sucker, to some distance beyond the posterior testis not reaching caecal ends ; intestinal caeca ending midway between posterior testis and posterior extremity of body, ovary in midbody ... *C. jabalpurensis* sp.n.

Vitellaria extend from the intestinal bifurcation to the level of the ends of the caeca ; intestinal caeca terminating in the anterior portion of the post-testicular space ... *C. thomsi* Dollfus. 1950.

(*iii*) *a*2. Testes transversely elongated ; vitelline follicles extend from the level of ventral sucker to the mid-way between testes and the ends of the intestinal caeca. *C. emydalis* Moghe, 1930. (Syn. *C. gangeticus* Pande, (1932)). (Syn. *C. magnus* Sinha, (1932)).

Testes rounded ; vitelline follicles extend from immediate anterior of ventral sucker to a little behind the anterior margin of posterior testis. *C. burmanicus* Chatterji, 1936.

(*iv*) Oesophagus present ; vitellaria from half-way between the oral sucker and ventral sucker to about the middle of anterior testis. *C. kumarus* Gupta, 1954.

Oesophagus absent ; vitellaria extend from near the intestinal bifurcation to the hinder margin of the ovary. *C. mehrai* Pande, 1932.

B2. Oesophagus present ... (*v*)

Oesophagus absent .. (*vi*)

(*v*) Testes obliquely placed ; genital pore in front of the oral sucker ; vitellaria extend from half-way between the oral and the ventral sucker upto the middle of the anterior testis. *C. indicus* Gupta, 1954.

Testes tandem ; ventral sucker half of oral sucker intestinal caeca extendieg only slightly behind the ventral sucker, vitelline follicles lateral, distributed between the ends of the caeca. *C. retusus* Dujardin, 1845.

(*vi*) Testes tandem in position, transversely elongated; vitellaria extend from the intestinal bifurcation to the middle of anterior testes. — *C. asiaticus* Gupta, 1953.

Summary

Three new species namely *Cephalogonimus gogatei* sp.n. *Cephalogonimus jabalpurensis* sp.n. *Cephalogonimus moghei* sp.n. have been described from Jabalpur and its viscinity.

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